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Volume Seven Number Two

SCHOOL OF MINES AND METALLURGY

UNIVERSITY OF MISSOURI

BULLETIN

MARCH, 1915

1914——CATALOGUE——1915

Rolla, Missouri

Entered as second-class matter January 7, 1909, at the post-office at Rolla, Missouri, under the act of July 18, 1894. Issued Quarterly

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SCHOOL OF MINES

AND

METALLURGY

UNIVERSITY of MISSOURI

FORTY-FOURTH ANNUAL CATALOGUE

ROLLA, MISSOURI
1915

CALENDAR FOR 1915-1916

1915

JANUARY

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FEBRUARY

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1916

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JULY

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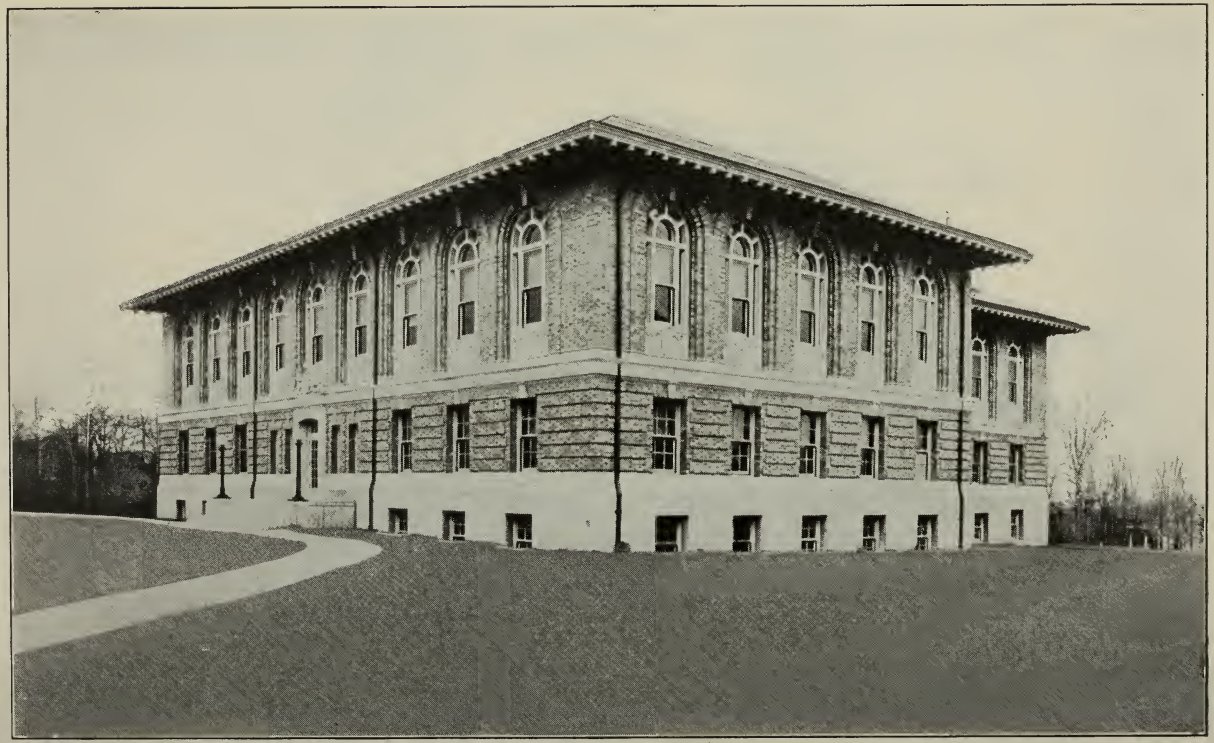
GYMNASIUM



PARKER HALL

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CALENDAR

1915

June 7, Monday - - - - - Summer School Begins
July 17, Saturday - - - - Summer School Closes
September 4, Saturday - - - Entrance Examinations
September 6, Monday - Registration for First Semester
September 7, Tuesday - First Semester Class Work Begins
November 25, Thursday - - - Thanksgiving Holiday
December 17, Saturday at 4 p. m. - Christmas Recess Begins

1916

January 1, Monday 8 a. m. - - Christmas Recess Ends
January 21, Friday - - - - First Semester Ends
January 22, Saturday - Registration For Second Semester
January 24, Monday - Second Semester Class Work Begins
May 26, Friday - - - - - Annual Commencement

BOARD OF CURATORS

S. L. Baysinger - - - - - - - - *Rolla, Mo.*

John H. Bradley - - - - - - - - *Kennett, Mo.*

D. R. Francis - - - - - - - - *St. Louis, Mo.*

H. B. McDaniel - - - - - - - *Springfield, Mo.*

Albert D. Nortoni - - - - - - - *St. Louis, Mo.*

J. C. Parrish - - - - - - - - *Vandalia, Mo.*

C. B. Rollins - - - - - - - - *Columbia, Mo.*

Sam Sparrow - - - - - - - - *Kansas City, Mo.*

G. L. Zwick - - - - - - - - *St. Joseph, Mo.*

OFFICERS OF THE BOARD

D. R. Francis - - - *President*

C. B. Rollins - - - *Vice-President*

J. G. Babb - - - - *Secretary*

R. B. Price - - - - *Treasurer*

EXECUTIVE COMMITTEE OF THE SCHOOL OF MINES AND METALLURGY

S. L. Baysinger - - - - - - - - - *Rolla*

Albert D. Nortoni - - - - - - - - *St. Louis*

G. L. Zwick - - - - - - - - - - *St. Joseph*

OFFICERS OF THE COMMITTEE

S. L. Baysinger - - - *Chairman*

G. L. Zwick - - *Vice-Chairman*

Edw. Kahlbaum - - - *Secretary*

C. M. Knapp - - - - *Treasurer*

FACULTY

ALBERT ROSS HILL,
President of the University.
A. B., Dalhousie University, 1892; Ph. D., Cornell University, 1895; LL. D., University of South Carolina; 1905; Dalhousie University, 1908; Westminister College, 1909; Washington University, 1915.

*AUSTIN LEE McRAE,
Director and Professor of Physics.
B. S., University of Georgia, 1881; S. D., Harvard University, 1886.

JOSEPH WAYNE BARLEY,
Professor of English and Modern Languages.
A. B. 1897; A. M., 1905; William Jewell College; Ph. D., University of Pennsylvania, 1911.

DURWARD COPELAND,
Professor of Metallurgy.
B. S., Massachusetts Institute of Technology, 1903; Met. E. School of Mines, 1915. (On leave during 1915-16).

GUY HENRY COX,
Professor of Geology and Mineralogy.
B. S. in General Science, Northwestern University, 1905; M. A., University of Wisconsin, 1908; Ph. D., University of Wisconsin, 1911; E. M., School of Mines, 1914.

GEORGE REINALD DEAN,
Professor of Mathematics.
C. E., School of Mines, 1890; B. S. in Mathematics and Physics, School of Mines, 1891.

CARROLL RALPH FORBES,
Professor of Mining.
B. S., Michigan College of Mines, 1902; E. M., Michigan Colleges of Mines, 1903.

VICTOR HUGO GOTTSCHALK,
Professor of Chemistry.
B. S. in Chemistry and Metallurgy, School of Mines, 1898; M. S., School of Mines, 1900.

*Elected Director. June, 1915.

ELMO GOLIGHTLY HARRIS,
Professor of Civil Engineering.
C. E., University of Virginia, 1882.

FRANK EDWARD DENNIE,
Associate Professor of Athletics and Physical Director.
B. S. in Civil Engineering, Brown University, 1909.

LEON ELLIS GARRETT,
Associate Professor of Mathematics.
B. S. in General Science, School of Mines, 1901.

HORACE THARP MANN,
Associate Professor of Metallurgy and Ore Dressing.
B. S. in Mining Engineering, School of Mines, 1904; M. S. in General Science, School of Mines, 1909; E. M., School of Mines, 1910.

JOSEPH HENRY BOWEN,
Assistant Professor of Shop Work and Drawing.
Graduate, Miller School, Virginia.

CHARLES YANCEY CLAYTON,
Assistant Professor in Ore Dressing and Metallurgy.
B. S. in Metallurgy, School of Mines, 1913.

CHARLES LAURENCE DAKE,
Assistant Professor of Geology and Mineralogy.
A. B., 1911, A. M., 1912; University of Wisconsin.

JOHN CHARAVELLE INGRAM,
Assistant Professor in Chemistry.
B. S. in General Science, School of Mines, 1913.

EDGAR SCOTT McCANDLISS,
Assistant Professor of Civil Engineering.
B. S. in Civil Engineering, Purdue University, 1909.

*JOSIAH BRIDGE,
Instructor in Geology and Mineralogy.
A. B., University of Cincinnati, 1913.

*WILLIAM FENN DeMOSS,
Instructor in English.
Ph. B., 1911; A. M., 1912, Chicago University.

**WALTER LOGIE DOBIE,
Instructor in Geology and Mineralogy.
University of Wisconsin.

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* Resigned, June, 1915.
** Elected, June, 1915.

RALPH EARL DUFFY,
Instructor in Drawing.
B. S. in E. E., University of Missouri, 1908.

FLOYD HILL FRAME,
Instructor in Physics and Electricity.
A. B., Clark College, 1912.

DONALD HEWSON RADCLIFFE,
Instructor in Geology and Mineralogy.
B. S., School of Mines, 1913.

WILLIAM HARRY RISHER,
Instructor in Mining and Surveying.
B. S. in C. E., Purdue University, 1912.

MARTIN HARMON THORNBERRY,
Instructor in Mathematics.
B. S., School of Mines, 1912.

GERALD THOMAS WILKINSON,
Instructor in Modern Languages.
A. B., Wabash College, 1911; A. M., Harvard University, 1912.

ORION DEXTER NEAL,
Assistant in Chemistry,
A. B., Indiana University, 1913; B. S., School of Mines, 1914.

STUDENT ASSISTANTS

BERNARD WILLIAM ADAMS,
Student Assistant in Physics.

BYRON LEE ASHDOWN,
Student Assistant in Surveying.

DANIEL WEBSTER BLAYLOCK,
Student Assistant in Surveying.

JAMES HENRY BOCK, JR.
Student Assistant in Shop Work.

LISTER MERRIKEN CUMMINGS,
Student Assistant in Mining.

AZMAN THURMAN DUNHAM,
Student Assistant in Drawing.

WALTER GAMMETER,
Student Assistant in Drawing.

KENRICK IRVING GANNON,
Student Assistant in Surveying.

FRED GROTTS,
Student Assistant in Chemistry.

GUNNARD EDMUND JOHNSON,
Student Assistant in Chemistry.

EARL JOESTING McNELY,
Student Assistant in Assaying.

EDWARD LOUIS SAILER,
Student Assistant in Surveying.

JOHN WARDER SHOTWELL,
Student Assistant in Mineralogy.

HOMER MARVIN WILSON,
Student Assistant in Mineralogy.

JOHN SKINNER WOOD,
Student Assistant in Shop Work.

FACULTY COMMITTEES

1915-1916

Admission.

DEAN, BARLEY AND INGRAM.

Advanced Standing.

GOTTSCHALK, WILKINSON AND FRAME.

Alumni Exchange.

FORBES, MANN, HARRIS, RADCLIFFE AND DUFFY.

Athletics.

COX, BOWEN, BARLEY, CLAYTON AND FORBES.

Buildings and Grounds.

HARRIS, MCCANDLISS AND DUFFY,

Degrees.

GOTTSCHALK, DEAN, DAKE AND MCCANDLISS.

Examination and Schedule.

FORBES, BOWEN, MANN, GARRETT AND DAKE.

Publications.

BARLEY, COX AND CLAYTON.

Student Council.

GARRETT, MANN, DENNIE, MCCANDLISS AND INGRAM.

Theses.

HARRIS, COX, FORBES AND MANN

Undergraduate Courses

MANN, COX, FORBES, INGRAM AND THORNBERRY.

HISTORY OF THE SCHOOL

In 1870 the General Assembly of Missouri, in accepting the donation of land for educational purposes made by the General Government through an Act of Congress, approved July 2, 1862, established an Agricultural and Mechanical College and a School of Mines and Metallurgy. The design of these institutions is set forth in the following language:

"Objects of These Colleges.—The leading objects of said colleges shall be to teach such branches as are related to agriculture and mining." (Revised Statutes, 1909, Section 11134.)

The School of Mines and Metallurgy was located at Rolla, Phelps County. Here, in November, 1871, the school was formally opened. The statues fix the status of the school as one of the Colleges of the State University. Its affairs are under the immediate supervision of an Executive Committee, consisting of three members of the University Board of Curators, selected by that body. The need of general culture as a foundation and accompaniment of specifically technical training led to the establishment, in 1885, of an Academic Course in compliance with the following Act of the General Assembly:

"Academic Course of Study, Etc.—That the obligation of the State to the General Government, assumed by the acceptance of the land grant of July 2d, 1862, may be more fully discharged, and in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life, the Board of Curators of the University of the State of Missouri shall prescribe and adopt a liberal academic course of study to be taught in the School of Mines and Metallurgy located at Rolla, in addition to the courses now taught in said school, and may confer the degree of bachelor of science upon all students who shall complete said course in said school to the satisfaction of the faculty thereof." (Revised Statutes, 1909, Section 11135.)

ROLLA BUILDING

NORWOOD HALL

FINANCES

The proceeds from the sale of the public lands granted by the General Government amount to about $350,000, which is invested in State certificates of indebtedness bearing 5 per cent interest. The School of Mines receives one-fourth of the yearly income thus accruing.

By an Act of Congress, approved August 30, 1890, commonly known as the "Morrill Bill," the General Government assists each State and Territory in maintaining a college or colleges in accordance with the act of July 2, 1862. After deducing one-sixteenth for the Lincoln Institute, Missouri gives one-fourth of the remainder of this fund to the School of Mines.

In 1891 the Government returned to the various States the sums collected from their citizens by the imposition during the Civil War of a "direct tax." The amount thus refunded to Missouri was $643,958.23, and the Thirty-sixth General Assembly of the State won the gratitude of the friends of higher education by establishing this as a permanent endowment for the State University at Columbia and the School of Mines and Metallurgy at Rolla. One-fifth of the income from this endowment is received by the School of Mines.

The Fortieth General Assembly of the State passed an act providing for a tax on collateral inheritances for the benefit of the State University, and the Forty-first General Assembly provided that one-fifth of the funds derived from this tax shall be appropriated for the benefit of the School of Mines.

ENDOWMENT

The State endowment of the School of Mines is set forth in the following extracts from the Statutes of Missouri:

"The proceeds of the sale of lands donated to the State of Missouri by the United States for the support of the College of Agriculture and Mechanic Arts and the School of Mines and Metallurgy, by Act of Congress, approved July 2, 1862, represented by State Certificates of indebtedness, of the following amounts and dates:

July 2, 1883	$242,000.00
November 1, 1883	5,000.00
January 29, 1884	5,000.00
April 19, 1884	35,000.00
April 2, 1885	5,000.00
February 25, 1886	5,000.00
January 1, 1888	5,000.00
December 15, 1888	5,000.00
May 15, 1889	5,000.00
July 1, 1891	5,000.00
May 15, 1893	5,000.00
July 1, 1895	22,881.19
April 9, 1895	5,000.00
Representing a total of	$349,881.19

Now issued or any certificates which may hereafter be issued under any general or special act of the General Assembly; one-fourth of the interest of these funds shall be paid to the Treasurer of the School of Mines and Metallurgy, at Rolla, for the maintenance of said institution."

"The proceeds of sales of lands donated to the School of Mines and Metallurgy, at Rolla, represented by the State certificate of indebtedness of $2,000, dated April 15, 1893, issued under act March 31, 1883, interest on which shall be applied to the maintenace of the School of Mines and Metallurgy, at Rolla."

"The State certificate of indebtedness of $3,000, issued under act of April 1, 1895, dated April 1, 1896, four-fifths of the interest to be applied to the maintenance of the State University, at Columbia, and one-fifth to the School of Mines and Metallurgy, at Rolla, and also any other certificates which may hereafter be issued and held in trust for this fund under any general or special act of the General Assembly." (Revised Statutes, 1909, Section 11161.)

In addition to the foregoing the School of Mines receives one-fourth of the interest on municipal and drainage district bonds amounting to $16,000.00, purchased under authority of Section 11168 of the Revised Statutes of 1909, amended by act approved April 7, 1911, Sess. Acts, 1911, p. 415.

"The State certificate of indebtedness of $646,958.23, derived from 'direct tax' received from the United States, dated April 1, 1891. issued under act of March 26, 1891, four-fifths of the interest to be applied for the maintenance of the State University, at Columbia, and one-fifth for the School of Mines and Metallurgy, at Rolla." (Revised Statutes, 1909, Section 11161.)

"All sums collected under the provisions of an Act of Congress, approved August 30, 1890, commonly known as the 'Morrill Bill,' shall be paid as follows: "One-sixteenth thereof for the benefit of the Lincoln Institute and one-fourth of the remainder to the Treasurer of the School of Mines, at Rolla, Missouri." (Revised Statutes, 1909, Section 11171.)

Collateral Inheritance Tax.—"The moneys received by the State Treasurer under the provisions of this article shall be deposited in the State Treasury to the credit of the fund now existing in the State Treasury, and known as the 'State Seminary Moneys,' for the maintenance, support and better equipment of the buildings, apparatus, books, instruction, etc., of the University of the State of Missouri, to an amount not exceeding in any one year the equivalent of one-tenth of one mill for every dollar of the assessed valuation of taxable property of the State for the said year; *Provided*, that one-fifth of all such moneys so received shall be devoted to the use of the School of Mines and Metallurgy, a department of the said University." (Revised Statutes, 1909, Section 312.)

LOCATION

The School of Mines is located at Rolla, the county seat of Phelps County, on the St. Louis and San Francisco Railroad, approximately halfway between St. Louis and Springfield.

Rolla is on the crest of the Ozark uplift, at an elevation of eleven hundred forty feet above the sea level, and has an agreeable and notably healthful climate. Its position on a great transcontinental railway system makes it readily accessible.

The school is within easy reach of the important mining districts of the State, which offer splendid facilities for the study of mining geology, mining methods, ore dressing, and mining machinery. Numerous recent improvements, due to the systematic study of Missouri ore deposits, methods of ore treatment, and the extensive development of low-grade lead and zinc ores, have given the school advantages for the application of the theories of geology, mining, and ore dressing to practice.

The smelting industry of the State is very important and every courtesy is extended to the professors and students of the school during their visits to these metallurgical plants. The methods of mining coal and clay can be readily studied in Missouri and the adjoining fields. Numerous clay-working and cement plants in St. Louis and vicinity offer good opportunity for the study of these important industries. In and about St. Louis are also various chemical plants which are visited from time to time.

CAMPUS AND ATHLETIC FIELD

The grounds of the School of Mines are situated in the highest part of the City of Rolla, and are over twenty-seven acres in extent. The campus contains beautiful laws, groves of native oak, and many shade trees.

The Jackling Field has a good baseball diamond, a football gridiron, tennis courts, and a 440-yard running track.

The new gymnasium is conveniently situated at the east end of the athletic field and is equipped with lockers, shower baths, dressing rooms, swimming pool and the usual gymnastic apparatus.

BLAST FURNACE

ASSAY LABORATORY

BUILDINGS

Rolla Building

This building was originally built by the City of Rolla as a High School building, but was sold to the State in 1871, and for many years was the principal building of the School of Mines and Metallurgy. It is a brick structure, ninety feet by sixty feet, four stories high, including a working basement. It contains the library, laboratories, drafting rooms, offices, and geological collections of the State Geological Survey, toilet, shower baths, and locker rooms.

Chemical Hall.

The main portion of this building was erected in 1885 and two wings were added in 1902. The main building is two stories high and one hundred two feet in length by fifty-five feet in width. Each wing is fifty-five feet by sixty feet and one story high. This entire building, including a large basement, is used for chemistry.

Mining Building and Power Plant.

This building, erected in 1895, is a tile-roof, press-brick structure, and consists of two distinct portions, one containing offices, an instrument room, and laboratories—the other comprising a large mining laboratory, an engine room, and a boiler room.

Mechanical Hall.

This two-story brick building, erected in 1901, is one hundred fifty feet by sixty feet and was specially designed for mechanical work. The second floor includes a demonstration lecture room, a shop for bench-work in wood, and a temporary gymnasium. The first floor contains a lathe room for wood-turning, a forge room, a metal-working room, and a stock and tool room.

Each floor is provided with a lavatory and lockers, and an office for the instructor.

Norwood Hall.

The corner stone of this building was laid November 23, 1902, and the building was first used in 1903. It contains adequate quarters for lecture and recitation rooms for physics, geology, mineralogy, civil engineering, English, mathematics; also drawing rooms and laboratories for physics, geology, mineralogy, and civil engineering.

Ore Dressing Building.

This is a three-story gray press-brick building with a basement and two large one-story wings. Two stories and the west wing has been in use since January, 1908, and the east wing was erected in 1909. The building provides quarters for metallurgy and ore dressing. The building was completed in 1911 and contains over twenty-five thousand square feet of floor space.

Parker Hall.

This is a fire-proof, two-story gray press-brick building, with a well-lighted basement. The main portion of the building is one hundred two by fifty-five feet and the wing is fifty-eight by sixty feet. The library occupies the second story of the building; the administrative offices, faculty room, and board room are located on the first floor; and the assembly room is in the two-story wing. This building was erected in 1912.

The Gymnasium.

This building, which is nearing completion, was made possible by the appropriation of seventy thousand dollars by the Forty-Seventh General Assembly. The Gymnasium is located at the north end of the campus, in a portion of Main street which was vacated by the city of Rolla for the purpose. The front is to the south, and the west side opens onto Jackling Feld.

The building occupies a space seventy-two feet wide and one hundred twenty-seven feet long, and is finished in dark red rough brick with gray terra-cotta trimmings. The interior is of fire-proof construction, with concrete and composition floors, except in the gymnasium proper, which is floored with maple. Tile partitions are used throughout the building, and the roof is concrete, supported by steel trusses and covered with asbestos roofing.

On the ground floor, entered by the main entrance on the south of the building, are the cloak rooms, locker rooms, training quarters and visiting-teams' room, shower baths and swimming pool. The swimming pool is twenty by sixty feet, finished in white enamel and equipped with all modern appliances. The water supplied to the pool is circulated with a small motor-driven pump, and a constant temperature is maintained by passing the water through a special steam boiler.

The mezzanine floor is on a level with Jackling Athletic Field, and opens upon a terrace which parallels the running track. On this floor are Committee rooms, general toilet rooms, the auxiliary gymnasium and balcony overhanging the swimming pool. On the second floor is the gymnasium-room proper. This room is seventy feet wide by ninety feet long and is to be well equipped.

The gallery of the gymnasium is a running track, with twenty-six laps to the mile. On this floor also is the examination room, office and reception room. At the south end of the building on the third floor and opening onto the running track is a large lounging and rest room.

Carpenter Shop.

The general repair work of the School and construction of laboratory equipment is carried on in a frame building, one hundred fifty feet by twenty-two feet. This building is located west of Mechanical Hall, and includes a store room for lumber.

THE LIBRARY

The library, which has been completely reorganized and catalogued during the past year, now occupies the second floor of Parker Hall. The new quarters consist of a large, well-lighted reading room, a stack room equipped with a double-deck Snead stack, capacity 45,000 volumes, and adequate work rooms for the library staff. All equipment is new and up-to-date, meeting in every way the needs of the library and its clientele.

The collection of books now numbers 18,000 carefully selected volumes, together with a large collection of pamphlets, bulletins, and reports of mining companies. The bulk of the collection consists of works in the sciences, chiefly geology, physics, and chemistry, and the useful arts, the main part of this division being engineering and mining treatises. Besides these collections, the library has the representative works in American and English literature, some fiction, a good section of biography, and the latest books of description and travel, this latter division being kept especially strong, so that the students may keep informed concerning the manners and customs of the people and the characteristics of the countries into which they are likely to go to follow their vocation.

The library is a subscriber to the leading technical periodicals and the publications and transactions of societies and congresses. The leading general magazines are taken for recreational reading. The contents of the back files of this material is made available through the general periodical indexes and the engineering and mining indexes.

The Dewey decimal system of classification is used and the resources of the collection are made available through a full dictionary catalogue of authors, titles, and subjects.

Interlibrary loan arrangements exist between this library and the Library of Congress, the St. Louis Public Library, John Crerar Library of Chicago, and the University Library at Columbia. By this arrangement books not in the collection at the School of Mines may be borrowed for the use of the students for a limited time.

During the past year the librarian has given lectures and instruction to the freshman and senior classes on the library methods employed and the use of the library.

The reading room is open daily from 7.45 to 12; 1 to 6; and 7 to 9; Sunday 2 to 5. Books and periodicals may be borrowed by all officers and students of the school, and by others having special permission.

ADMISSION

Under the statutes persons of either sex, sixteen years of age or over, whether residents of Missouri or not, may be admitted upon evidence of sufficient preparation. Students should have a good liberal education, its elements at least, before beginning technical study. The average age of members of the present Freshman class at entrance was about eighteen years. Specific requirements have been fixed by consideration of the express design of the school—"to promote the education of the industrial classes" in certain branches of engineering—and for the educational opportunities of its intended beneficiaries. The requirements for admission to the Freshman class are as follows:

The applicant must file with the Director a satisfactory certificate of good moral standing.

Admission by Examination.—Applicants for admission, not having diplomas from approved schools, are required to pass examinations in fifteen units, a unit being the equivalent of a year's work in one subject, as given in an approved high school. A condition will be allowed on two of these units. Such conditions must be made up during the first year.

Of these fifteen units the following are required: Three units in English, one and one-half units in Algebra, one unit in Plane Geometry, and one-half in Solid Geometry. The remaining nine units may be selected from the following list:

Subject	Maximum.	Minimum.
English	4	3
Algebra	1½	1½
Plane Geometry	1	1
Solid Geometry	½	½
Trigonometry	1	½
History	4	1
Civil Government	½	½
Latin	4	2
Greek	3	2
German	3	2
French	3	2
Spanish	3	2
Physics	2	1
Chemistry	2	1
General Biology	2	1
Zoology	2	1

Botany	2	1
*Physiology	1	1
Physical Geography	1	1
Drawing	2	1
**Manual Training	2	1
**Economics	½	½
**Commercial Geography	½	½
**Bookkeeping	1	1

MATHEMATICS. (4 UNITS.)

The four units which may be offered in mathematics are as follows:

ALGEBRA. (1½ UNITS.) Elementary algebra, including the elementary operations, solution of simple and simultaneous linear equations, factoring, radicals, exponents, quadratic equations, equations containing radicals, imaginaries, simultaneous quadratics, higher equations solved as quadratics, relations of roots and coefficients of quadratics and higher numerical equations, solution of higher equations by factoring, Horner's method of approximation, binominal theorem for positive integral exponent, ratio and proportion, and logarithms.

While the study of these particular subjects is recommended, it is not expected that the student shall be able to pass an examination on each and every one of them. He must produce evidence, however, of having studied algebra for one and one-half years under a good teacher in an accredited high school.

PLANE GEOMETRY. (1 Unit.) The work in plane geometry must cover a full year in any good text. It is recommended that considerable attention be paid to the applicants of algebra to geometry, and of geometry to algebra and arithmetic.

SOLID GEOMETRY. (½ Unit.) A full half-year's work is required in solid geometry. The same recommendations apply here as in plane geometry, with the additional requirement that the student be drilled in arithmetical work in computing areas and volumes.

TRIGONOMETRY. (1 Unit.) It is to be understood at the outset that this work will not be accepted for advanced standing. This branch of mathematics is of such great importance to the practical engineer that the whole subject must be reviewed, and the student led to a point of view which it is impossible to attain in a high school course.

* In cases where the study of Physiology has been preceded by a year's study of Biology.

** The maximum amount of commercial and industrial subjects accepted is four units.

ENGLISH. (4 UNITS.)

The four units that may be offered in English include grammar, composition and rhetoric, and literature.

The candidate will be required to show a reasonable proficiency in the principles of English grammar, including sentence-analysis. He will be required to show the ability to express himself coherently and correctly, with a fair mastery of the forms of writing, spelling and punctuation, sentence and paragraph structure. He will be examined on the literature listed below, and, if he desires four units, will be required to show also a knowledge of the history of English literature.

The classics prescribed are as follows:

I. For Study and Practice, Shakespeare's *Macbeth*; Milton's *Lycidas, Comus, L'Allegro* and *Il Penseroso*; Burke's *Speech on Conciliation* or Washington's *Farewell Address*, and Webster's *First Bunker Hill Oration*; Macaulay's *Life of Johnson* or Carlyle's *Essay on Burns.*

II. For Reading. Group 1 (two to be selected): Shakespeare's *As You Like It*; *Henry V.*; *Julius Caesar*; *The Merchant of Venice*; *Twelfth Night.*

Group 2 (one to be selected): Bacon's *Essays*; Bunyan's *The Pilgrim's Progress*, Part I.; Addison's *Sir Roger de Coverley*; Franklin's *Autobiography.*

Group 3 (one to be selected): Chaucer's *Prologue*; Spenser's *Faerie Queene* (Selections); Pope's *The Rape of the Lock*; Goldsmith's *The Deserted Village*; Palgrave's *Golden Treasury* (First Series), Books II. and III., with especial attention to Dryden, Collins, Gray, Cowper, and Burns.

Group 4 (two to be selected): Goldsmith's *The Vicar of Wakefield*; Scott's *Ivanhoe*; Scott's *Quentin Durward*; Hawthorne's *The House of the Seven Gables*; Thackeray's *Henry Esmond*; Mrs. Gaskell's *Cranford*; Dickens' *A Tale of Two Cities*; George Eliot's *Silas Marner*; Blackmore's *Lorna Doone.*

Group 5 (two to be selected): Irving's *Sketch Book* (Selections); Lamb's *Essays of Elia*; DeQuincey's *Joan of Arc* and *The English Mail Coach*; Carlyle's *Heroes and Hero Worship*; Emerson's *Essays* (Selected); Ruskin's *Sesame and Lilies.*

Group 6 (two to be selected): Coleridge's *The Ancient Mariner*; Scott's *The Lady of the Lake*; Byron's *Mazeppa* and *The Prisoner of Chillon*; Palgrave's *Golden Treasury* (First Series), Book IV., with especial attention to Wordsworth, Keats and Shelley; Macaulay's *Lays of Ancient Rome*; Poe's *Poems*; Lowell's *The Vision of Sir Launfal*; Arnold's *Sohrab and Rustum*; Longfellow's

The Courtship of Miles Standish; Tennyson's *Lancelot and Elaine, The Passing of Arthur, Gareth and Lynette*; Browning's *Cavalier Tunes, Lost Leader, How They Brought the Good News from Ghent to Aix, Evelyn Hope, Home Thoughts from Abroad, Home Thoughts from the Sea, Incident of the French Camp, The Boy and the Angel, One Word More, Herve Riel, Pheidippides.*

HISTORY.

Four units may be offered in history; one each in Ancient History, Medieval and Modern History, English History, and American History.

CIVIL GOVERNMENT.

One-half unit may be offered in Civil Government. This is the equivalent of one-half year's work in the fourth year of a high school and the applicant should have a knowledge of the chief organs of local, state, and national government and a knowledge of the historical development of the government.

PHYSIOGRAPHY.

A student may offer one unit in physiography. A description of this unit will be sent on request.

PHYSICS.

The two units that may be offered in physics are as follows:

1. A year's work, five periods per week, of which at least two must be double periods in individual laboratory work. At least thirty-five exercises, selected from a list of sixty or more, equivalent to those recommended by the National Educational Association, must be completed.

2. A continuation of the laboratory for another year, or a year's work in a more advanced text together with the laboratory work.

Laboratory note-books must be presented by those who are required to take the entrance examination.

DRAWING.

Two units may be offered.

The following outline recently adopted by the North Central Association of Colleges and Secondary Schools, indicates the nature of the work which should be included in the two units of drawing. While the work is not separated here, into a first and second year program, the more elementary forms of each phase of the subject should be selected for the first year.

a. Pictorial. Plant study (flowers, sprays of leaves, seeds

pods, etc.). Object study (elementary perspective). Landscape (roof studies, buildings, etc., elementary perspective). Pose drawing.

b. Decorative Composition. Plant forms, object study, landscape pose.

c. Decorative Design. Plant analysis (for the purpose of design). Decorative units, borders, surfaces, corners, rosettes, posters, book-covers, etc. Arrangement of straight lines, and of straight and curved lines. Geometric design. Lettering (printing).

d. Constructive Design. Designs for pottery, leather, cardboard, construction, etc.

e. Crafts. Pottery, leather (choice of one).

f. Applied Design. Design applied to cardboard, textiles, etc.

g. Instrumental Drawing such as is needed to meet the requirements of practical designing and construction.

The candidate should have some knowledge of the history of the industry and art, and some knowledge of civic planning, domestic architecture and decoration.

NOTE.—Mediums used are pencil, charcoal, water color, crayons, brush and ink, and a combination of the pure mediums.

MANUAL TRAINING.

Two units in manual training may be offered. One unit should be in Bench Work and one in Mechanical Drawing. The time required in each of these subjects is five double period for one year or five single periods for two years. Where conditions permit it is generally advisable to give these subjects as parallel courses.

LATIN.

The four units that may be offered in Latin are as follows:

1. Collar and Daniel's First Latin Book, or the equivalent.

2. Three books of Caesar's Gallic War with composition based thereon in Moulton and Collar's Preparatory Latin Composition or in Daniell's New Latin Composition. For one book of the Gallic War the equivalent in time of Viri Romae, Nepos, or Eutropius may be offered.

3. Two additional books of the Gallic War and four Orations of Cicero with compositions based thereon in the books mentioned above.

4. Ovid's Metamorphoses (2,000 lines) and four books of Virgil's Aeneid, with prosody.

GREEK.

The three units that may be offered in Greek are as follows:

1. Ball's Elements of Greek, or White's First Greek Book.

2. Four books of Xenophon's Anabasis, Pearson's Greek Prose Composition, or its equivalent, Goodwin's Greek Grammar.

3. Ten Orations of Lysias and the first four books of Homer's Odyssey, or an equivalent amount of other Greek authors. Bridgman's Parallel Exercises based on Lysias.

GERMAN, FRENCH, SPANISH.

Three units may be offered in German, French, or Spanish. A description of the units will be sent on request. These units will not be accepted for advanced standing.

CHEMISTRY.

The two units that may be offered in chemistry are as follows:

1. A year's work in chemistry, five periods per week, of which at least two must comprise laboratory work.

2. A second year's work in the subject, five periods per week, of which at least two must be laboratory work.

Note-books showing work done must be presented by those who are required to take the entrance examinations.

These courses will be accepted for admission, but not for advanced standing.

BOOKKEEPING.

One unit may be offered.

The student should become familiar with the meaning of double entry terms, with rules for debit and credit, and the kinds and uses of books. He should acquire the ability to keep a double entry and a single entry set of books. Furthermore, he should become familiar with such standing business forms as bills, receipts, checks, notes, time and sight drafts, endorsements, invoices, accounts, sales, deposit tickets, express receipts, bills of lading; statements of account, balance sheets, etc. He should become familiar also with the forms of business letters, beginnings and endings, etc., and should know how to write and answer telegrams and advertisements.

Bookkeeping should be done largely under the eye of the teacher as laboratory work. Good penmanship, neatness in work, accuracy and speed must be acquired in such laboratory practice. The exercises in some of the texts which are offered by the various publishers on first lessons or elementary principles would naturally form the basis for much of such work, unless the teacher prepares his own exercise work according to a similar plan. The

best evidence of good work in this subject is the character of exercise work which the student can present as a result of his laboratory practice.

Some of the best reference works, useful especially to the teacher in charge of elementary work, are Sprague's *Philosophy of Accounts*, Hatfield's *Modern Accounting*, Lisle's *Accounting in Theory and Practice*, Dicksee's *Bookkeeping for Accounting Students*, and Cole's *Accounts—Their Construction and Interpretation.*

COMMERCIAL GEOGRAPHY.

One-half unit may be offered.

The object of this course is to discover the causes of the present territorial distribution of industries and of the location of lines of communication and transportations. It should treat in detail with reference to the United States, and in less detail with reference to the outlying possessions of the United States and to the most important commercial countries, the following topics: (1) the effect of surface, soil, climate, etc. that is, the physical factor in commerce; (2) the influence of race, religion, education, commercial policies, etc. that is, the human factor in commerce; (3) the effect of economic forces on production and commerce; (4) means of transportation and communication. The text-book should be supplemented by map work and assigned readings. The census of manufactures in the United States and other countries would form a valuable reference library both for the purpose of map work and assigned readings.

It is desirable that for purposes of illustration, samples of commercial staples, lantern slides, stereopticon pictures, etc., should be freely employed; and wherever possible, that visits of inspection be made and informal lectures secured by experts in various industries. Commercial Geography should be preceded by Physical Geography, in case both are given.

Admission by Certificate.—Graduates of a four years accredited high school, or the equivalent, having not less than fifteen units of high school credit including the required units mentioned on page 21 are admitted to the school of Mines without examination upon the presentation of a certificate signed by the principal or superintendent.

Following is a list of schools whose courses have been approved by the University, and whose diplomas will admit to the Freshman class without examination.

ACCREDITED SCHOOLS

Adrian High School
Albany High School
Armstrong High School
Ash Grove High School
Aurora High School
Bartlesville (Okla) High School
Belton High School
Bethany High School
Bloomfield High School
Bolivar High School
Bonne Terre High School
Boonville High School
Bosworth High School
Bowling Green High School
Braymer High School
Breckenridge High School
Brookfield High School
Brunswick High School
Burlington Junction High School
Butler High School
Cainesville High School
California High School
Cameron High School
Campbell High School
Canton High School
Cape Girarderu High School
Carleton College (Farmington)
Carrollton High School
Carthage High School
Caruthersville High School
Central College Academy (Fayette)
Centralia High School
Charleston High School
Chillicothe High School
Clayton High Schsol
Clinton High School
Columbia High School
Dearborn High School
Desloge High School
De Soto High School
Dexter High School
Doniphan High School
Edina High School
Eldon High School
Eldorado Springs High School
Ellsberry High School
Enid (Okla.) High School
Everton High School
Excelsior Springs High School
Fairfax High Schcol
Farmington High School
Fayette High School
Ferguson High School
Flat River High School
Fort Smith (Ark.) High School
Fredericktown High School
Fulton High School
Gallatin High School
Gilman City High Rchool
Golden City High School
Gorin High School
Grant City High School
Green City High School
Greenfield High School
Greenville High School
Greenville (Miss.) High School
Hale High School
Hamilton High School
Hannibal High School
Hardin High School
Harrisonville High School
Hickman Mills High School (Ruskin)
Higginsville High School
Holden High School
Hopkins High School
Hosmer Hall (St. Louis)
Hot Springs (Ark.) High School
Houston High School

Huntsville High School
Independence High School
Ironton High School
Jackson High School
Jamesport High School
Jasper High School
Jefferson City High School
Joplin High School
Kahoka High School
Kansas City Central High School
Kansas City Manual Training High School
Kansas City Northeast High School
Kansas City Westport High School
Kemper Military School (Boonville)
Kennett High School
Keytesville High School
King City High School
Kirksville High School
Kirkwood High School
Knobnoster High School
LaBelle High School
Lamar High School
Lancaster High School
La Plata High School
Lathrop High School
Lebanon High School
Lee's Summit High School
Lenox Hall (St. Louis)
Lexington High School
Liberty High School
Linneus High School
Little Rock (Ark.) High School
Lockwood High School
Logan County (Guthrie, Okla.) High School
Louisiana High School
McAlester (Okla.) High School
Macon High School
Maitland High School
Malden High School
Maplewood High School
Marceline High School
Marionville College
Marionville High School
Marshall High School
Marshfield High School
Mary Institute (St. Louis)
Maryville High School
Maysville High School
Meadville High School
Memphis High School
Mexico High School
Miami (Okla.) High School
Milan High School
Missouri Christian College (Camden Point)
Moberly High School
Monett High School
Monroe City High School
Montgomery City High School
Mound City High School
Mountain Grove High School
Mt. Vernon High School
Muskogee (Okla.) High School
Neosho High School
Nevada High School
New Franklin High School
New Haven High School
New London High School
New Madrid High School
Norborne High School
Odessa High School
Oklahoma City (Okla.) High School
Oklahoma Institute of Technology
Okmulgee (Okla.) High School
Oregon High School
Osceola High School
Palmyra High School
Paris High School
Pattonsburg High School
Pawnee (Okla.) High School
Peirce City High School
Perry High School
Perryville High School
Piedmont High School

Pine Bluff (Ark.) High School
Platte City High School
Plattsburg High School
Pleasant Hill High School
Polo High School
Poplar Bluff High School
Potosi High School
Princeton High School
Principia, The (St. Louis)
Republic High School
Richmond High School
Ridgeway High School
Rockport High School
Rosati-Kain High School (St. Louis)
St. Charles High School
Ste. Genevieve High School
St. James High School
St. Joseph's Central High School
St. Joseph's Academy (St. Louis)
St. Louis Central High School
St. Louis Manual Training School
St. Louis McKinley High School
St. Louis Soldan High School
St. Louis Yeatman High School
St. Teresa's Academy (Kansas City)
St. Vincent's Academy, (St. Louis)
Salem High School
Salisbury High School
Sarcoxie High School
Savannah High School
Sedalia High School
Seymour High School
Shelbina High School
Shelbyville High School
Shreveport (La.) High School
Sikeston High School
Skidmore High School
Slater High School
Smith Academy (St. Louis)
Smithville High School
Springfield High School
Stanberry High School
Steelville High School
Sweet Springs High School
Tarkio High School
Tipton High School
Trenton High School
Troy High School
Tulsa (Okla.) High School
Union High School
Unionville High School
University High School (Columbia)
University Military School (Mobile, Alabama.)
Van Buren (Ark.) High School
Vandalia High School
Versailles High School
Vinita (Okla.) High School
Warrensburg High School
Warsaw High School
Washington High School
Webb City High School
Webster Groves High School
Wellston High School
Wellsville High School
Wentworth Military Academy (Lexington)
Weston High School
West Plains High School
Willow Springs High School
Windsor High School

Partially Accredited Schools:

Bevier High School
Bismarck High School
Buckner High School
Carterville High School
Cassville High School
Clarence High School
Craig High School
Cuba High School
Deepwater High School
East Prairie High School

Eureka High School
Festus High School
Garden City High School
Glasgow High School
Hermann High School
Higbee High School
Horner Institute (Purdy)
Kansas City Y. M. C. A. Night School
Kearney High School
Kidder Institute
Laclede High School
Laddonia High School
Lamonte High School
Madison High School
Miami High School
Oak Grove High School
Orrick High School
Otterville High School
Queen City High School
Rich Hill High School
Richland High School
Rolla High School
St. Joseph Benton H. S.
Sapulpa (Okla.) High School
Southwest Baptist College (Bolivar)
Sullivan High School
Thayer High School
Walther College (St. Louis)
Will Mayfield College
Woodson Institute (Richmond)
Wyaconda High School

Advanced Standing.—Candidates may be admitted to advanced standing either upon examination in the subjects of the previous year or years, or upon certificate from another institution of work accomplished, which is, in the estimation of the Faculty, equivalent to that completed here by the class into which entrance is sought. Applicants for advanced standing should communicate with the Director as early as possible, and all claims for advanced standing, in order to receive recognition, must be made by the students within one term after entrance.

Special Students.—Special students may be admitted without passing the regular examinations required for entrance, under the following conditions: 1. They must be at least twenty-one years of age. 2. They must show good reasons for not taking a regular course. 3. They must pass such examinations or other tests as shall demonstrate fitness to pursue profitably all the subjects selected by them. 4. They shall not be candidates for a degree. 5. Special students are expected to do particularly good work in the subjects which they choose. If, at any period of the session, their work becomes unsatisfactory, their connection with the school will be severed. When the work is chiefly of a laboratory nature they will be required to take at the same time as much class room work as the Faculty may designate for each particular case.

Since there are many persons who would profit by the opportunities for education offered at the school, but who are unable, through lack of time or preliminary training, to undertake the work of the regular course, the Faculty has made the above provision. In this way it hopes to broaden the usefulness of the school, and to enable it to fulfill its purpose in as liberal a manner as possible

CURRICULA

It is the object of the instruction at this institution, first, to lay a broad and solid foundation by acquaintance with principles and theory, and to supplement this, wherever possible, by the discipline of practical application in the laboratory and field. Lectures and recitations are arranged for the morning hours, leaving the afternoon for laboratory and field work. The practical work is designed to illustrate and impress principles, to familiarize the student with the use of instruments with which he is to be concerned in the work of his profession, and to afford an opportunity for original investigation. What is taught orally in the lecture room is applied and illustrated in the laboratory.

The courses are the same in the Freshman year and differ but slightly in the Sophomore year. The student has thus an opportunity to defer his choice of a specialty until he has spent some time in technical study, and can better estimate his inclinations and capacities.

One hour is given to each recitation or lecture period. The afternoon periods are given to drawing, laboratory, and field work, and are of three hours' duration; one laboratory period of three hours is rated as equivalent to one and one-half credits.

The School of Mines and Metallurgy offers the following curricula:

I. Mine engineering, leading to the degree of Bachelor of Science in Mine Engineering. This is a general course in Mine Engineering, having in view all the operations in connection with mining from the prospective to the delivery of the finished product on the market.

The entire Senior year is elective and the schedule of hours is so arranged that electives may be chosen to make up groups of studies as follows: Metal Mining; Coal Mining; Mining Geology; Mining, Metallurgy, and Ore Dressing; Mining Machinery; and Mining.

II. Metallurgy, leading to the degree of Bachelor of Science in Metallurgy. This curriculum contemplates especially processes in Metallurgy subsequent to the delivery of ore above ground. It fits a man for positions in connection with concentrating plants and smelters and various branches of industrial chemistry.

III. Civil Engineering, leading to the degree of Bachelor of Science in Civil Engineering. This is a curriculum in engineering as applied especially to railways, highways, and municipal works.

IV. General Science, leading to the degree of Bachelor of Science in General Science. This curriculum is largely elective and provides for a liberal education in science.

V. Graduate Curriculum in Mine Engineering, leading to the degree of Engineer of Mines. The curriculum is open to Bachelors of Science in Mine Engineering.

VI. Graduate Curriculum in Metallurgy, leading to the degree of Metallurgical Engineer. This curriculum is open to Bachelors of Science in Metallurgy.

VII. Graduate Curriculum for Engineers, leading to the degree of Engineer of Mines. This curriculum is open to Bachelors of Science in Civil, Electrical, or Mechanical Engineering.

The school reserves the right to omit for any semester any subject for which at least three students do not register.

GRADUATE COURSES

The School of Mines offers graduate work in Mining Engineering, Metallurgy, Ore Dressing, Geology, Economic Geology, Petrography, and Advanced Chemistry. The attention of graduates of engineering schools and of mining schools is directed to the following courses:

Mine Management
Mining Machinery
Mining Machinery Laboratory
Mining Law
Mine Examination and Reports
Mine Plant
Mine Plant Design
Mine Power Plant
Mining Economics
Economic Geology
Geology of the United States
Structural and Metamorphic Geology
Petrography
Petrography Laboratory
Cement and Concrete Structures
Compressed Air
Compressed Air Laboratory
Engineering Designs
Ore Dressing Laboratory
Ore Dressing Problems
Ore Supply
Metallurgy Organization
Metallography
Constitution of Alloys
Metallurgical Problems
Metallurgical Plant
Metallurgical Plant Design
Cyaniding
Electro-Metallurgy
Electro-Metallurgy Laboratory
Metallurgical Research
Electro-Chemistry
Water Analysis
Physical Chemistry
Theoretical Chemistry
Advanced Physico-Chemical Laboratory
Internal Combustion Engines

Graduates from the four-year curriculum in Mining Engineering may pursue graduate work leading to the degree of Engineer of Mines. Electives may be chosen along any line approved by the Faculty.

A similar graduate curriculum is offered in Metallurgy. This leads to the degree of Metallurgical Engineer.

Graduates in Civil, Electrical, and Mechanical Engineering, who desire to specialize in Mining, may secure the degree of Engineer of Mines by complying with VII on page 33. Considerable latitude will be granted men who are qualified to undertake research work.

SPECIAL COURSES

In addition to the ten regular curricula leading to degrees, before mentioned, a number of shorter courses are also offered. They are: *Chemistry and Assaying, Mining, Surveying, and Electricity.* They have been planned for the benefit of those who for various legitimate reasons, are unable to take the regular four-year courses.

The course in *Assaying and Chemistry* requires two years' work, although mature students, who have already some knowledge of chemistry, may complete it in one year.

The purpose of the course in *Surveying* is to develop competent land and mining surveyors and fair draftsmen. The essentials of it are a thorough knowledge of algebra, trigonometry, surveying, field practice, and drawing. One school year and the first term of a second year will be required for the completion of this course.

A short course in *Mining* is offered to students, especially such as have had some practical experience, who may wish to fit themselves for holding important positions about mines or in ore-dressing plants, but who are unable, on account of the lack of preparation or of time, to take the full course in Mining Engineering. Besides mathematics this course includes general chemistry, assaying, mineralogy, geology, mining, surveying and English.

A course in *Electricity* is offered to furnish the student with the theory of electricity, and acquaint him with its application in the arts. This subject is of great importance to every engineer, especially to the mining engineer, since electricity has become such an important factor in mining operations.

DEGREES

I. The degree of Bachelor of Science in Mine Engineering will be conferred upon a candidate for a degree who has completed the prescribed work of the first three years of Curriculum I., sixty-two units elective work, and all of the required trips of Curriculum I. The final years' work must be done in residence.

II. The degree of Bachelor of Science in Metallurgy will be conferred upon a candidate for a degree who has completed the prescribed work of the first three years of Curriculum II., sixty-two units elective work including a thesis, and all of the trips required in Curriculum II. The final year's work must be done in residence.

III. The degree of Bachelor of Science in Civil Engineering will be conferred upon a candidate for a degree who has completed the required subjects and the prescribed number of electives of Curriculum III., and a satisfactory thesis. The final year's work must be done in residence.

IV. The degree of Bachelor of Science in General Science will be conferred upon a candidate who has completed the prescribed subjects and electives of Curriculum IV., and a satisfactory thesis. Candidates for degrees in General Science must matriculate in the General Science Curriculum not later than the beginning of the Junior year. The final year's work must be done in residence.

V. The degree of Engineer of Mines, Metallurgical Engineer, Civil Engineer, will be conferred upon a candidate who holds the degree of Bachelor of Science in Mine Engineering, Bachelor of Science in Metallurgy, Bachelor of Science in Civil Engineering, respectively, and who has completed in residence fifty-three units and a satisfactory thesis; or upon a graduate in Curriculums I., II., III., respectively, who has had professional experience in a responsible position for not less than three years. A satisfactory thesis recording the result of some original investigation or independent research in a subject connected with his work, accompanied by such drawings as may be necessary to illustrate it, is required of each candidate for an advanced degree.

A candidate for a professional degree is required to submit a list of companies for whom he has worked, with the positions held, the kind of work done, and the length of service.

When a candidate's professional work has been along another line than that in which he received his college training, he may receive the professional degree in that line after five years of practice and by complying with the foregoing statement concerning detailed report of employment and thesis.

Only one professional degree will be allowed for work done *in absentia.*

VI. The degree of Master of Science will be conferred only upon graduates in General Science who have completed a year's graduate work in residence and demonstrated ability by research work and a thesis. Each candidate who is not a graduate of this institution in Curriculum IV. must satisfy the language requirements of Curriculum IV., in addition to completing the graduate requirements. A candidate who is not giving his entire time to graduate study will be unable to earn the degree in one year's residence.

VII. The degree of Engineer of Mines will be conferred upon a candidate who completes Curriculum VII, page 49.

THESES

All Seniors, except those in courses where this subject is elective, are required to carry on special investigations during the second semester and the results of this work are embodied in a thesis. The subject of the thesis must be reported to the Thesis Committee of the Faculty and approved not later than January fifteenth. The completed thesis must be filed with the Director not later than May twentieth.

The finished thesis should be typewritten (or printed) on eight and one-half by eleven-inch paper, written on one side only. The paper should be strong linen, unruled and without marginal lines. The thesis should be typewritten so as to have a margin all around of not less than one and one-half inches.

The thesis should have:

(1) A title page containing the subject of the thesis, the writer's name, and the date. It should show the approval of the professor under whose direction the work has been done and should also state the degree for which the candidate is an applicant.
(2) A table of contents.
(3) A list of illustrations.
(4) The body of the thesis including illustrations.
(5) A bibliography.
(6) An index.
(7) Original drawings or tracings.

All theses submitted by candidates for degrees become the property of the School of Mines and Metallurgy and may not be published without its approval.

I. MINE ENGINEERING CURRICULUM

Department	No.	Course	Page	Hrs. per week		Hours credit
				Lect.	Lab.	
FRESHMAN YEAR.						
First Semester.						
Chemistry	1a	General Chemistry	51	5		5
Chemistry	2a	Chemistry Laboratory	51		6	3
English	1a	Rhetoric and Composition	73	5		5
Mathematics	1a	College Algebra	85	5		5
Mathematics	3a	Plane Trigonometry	85			
Shop Practice and Drawing	1a	Descriptive Geometry	117	1	4	3
Shop Practice and Drawing	2a	Mechanical Drawing	117		6	3
Shop Practice and Drawing	12a	Woodwork	118		6	3
Mining	1a	Mining	104	2		2
Second Semester						
Chemistry	1b	General Chemistry	51	5		5
Chemistry	3b	Qualitative Lectures	52	2		2
Chemistry	4b	Qualitative Laboratory	52		6	3
English	1b	Rhetoric and Composition	73	5		5
Mathematics	5b	Spherical Trigonometry	85			
Mathematics	7b	Analytical Geometry	86	5		5
Shop Practice and Drawing	2b	Mechanical Drawing	117		6	3
Shop Practice and Drawing	14b	Forge Shop	118			3
SOPHOMORE YEAR						
First Semester						
Chemistry	5a	Quantitative Analysis	52	2		2
Chemistry	6a	Quantitative Laboratory	52		6	3
Civil Engineering	2a	Field Practice	73		9	5
English	3a	English Prose	79	3		3
Geology and Mineralogy	1a	Mineralogy	86	2	6	5
Mathematics	9a	Differential Calculus	86			
Mathematics	11a	Integral Calculus	86	4		4
Mining	3a	Mining	104	3		3
Modern Languages	7a	German	75			
Modern Languages	9a	French, or	75	3		3
Modern Languages	11a	Spanish	75			
Second Semester						
Chemistry	6b	Quantitative Laboratory	53		6	3
English	3b	English Prose	74	3		3
Geology and Mineralogy	1b	Mineralogy	79	2	6	5
Mathematics	11b	Differential Equations	86			
Mathematics	13b	Integral Calculus	86	5		5
Mining	5b	Mine Surveying	104	2		2
Mining	6b	Mine Surveying Lab	105		3	1.5

I. MINE ENGINEERING CURRICULUM—*Continued*

Department	No.	Course	Page	Hours Per Week		Hours Credit
				Lect.	Lab.	
Modern Languages	7b	German	75			
Modern Languages	9b	French, or	75	3		3
Modern Languages	11b	Spanish	75			
Physics	1b	General Physics	112	4		4
Physics	2b	Physics Laboratory	112		3	1.5
Mining	6	Mine Surveying, Field Work	105			3
Civil Engineering	4	Topography	65			1 5
JUNIOR YEAR						
Civil Engineering	7a	Railroad Surveying	66	2		2
Civil Engineering	8a	Field Practice	66		3	1.5
Geology and Mineralogy	3a	General Geology	80	4		4
Geology and Mineralogy	5a	Lithology	81	1	3	2.5
Mathematics	15a	Statics	87	2		2
Mathematics	17a	Mechanics of Materials	87	2		2
Mining	16a	Mining Laboratory	107		3	1.5
Physics	3a	Physics	113	4		4
Physics	4a	Physics Laboratory	113		3	1.5
Physics	5a	Thermodynamics	113	3		3
Physics	6a	Steam Laboratory	113		3	1.5
Second Semester						
Civil Engineering	9b	Hydraulics	66	3		3
Civil Engineering	10b	Hydraulic Problems	66		3	1.5
Civil Engineering	11b	Masonry	67	2		2
Civil Engineering	20b	Engineering Laboratory	70		3	1.5
Geology and Mineralogy	3b	General Geology	80	4		4
Geology and Mineralogy	4b	Geology Laboratory	80		6	3
Mathematics	19b	Mechanics of Materials	87	2		2
Mathematics	21b	Dynamics	87	2		2
Metallurgy and Ore Dressing	1b	Fire Assaying	90	2		2
Metallurgy and Ore Dressing	2b	Assaying Laboratory	90		9	4.5
Metallurgy and Ore Dressing	3b	General Metallurgy	91	3		3
Metallurgy and Ore Dressing	31b	Elements of Ore Dressing	97	2		2

Students who wish to specialize in Coal Mining may substitute machine drawing and machine shop for chemistry 6b, and metallurgy and ore dressing 2b.

Mine ventilation lectures may be substituted for metallurgy and ore dressing 1b by students specializing in coal mining.

Note: Credit will not be allowed for these substitutions unless followed by coal mining courses of senior year.

I. MINE ENGINEERING CURRICULUM.

SENIOR YEAR.

To receive the degree of Bachelor of Science in Mine Engineering, each candidate must have completed, in addition to the work of the first three years already noted, a total of sixty-two credit hours, including Geology 9a or 9b, Metallurgy 33a and 33b, Mining 11b, and such parts of the senior trips as may be required by other courses; the remaining hours may be chosen from the courses listed below.

Chemistry 15a.

Civil Engineering 15a, 16a, 17b, 23a, 27a, 28a.

English and Modern Languages 17a and 17b, or 19a.

Geology 7a, 9a, 9b, 11a, 11b, 14a, 15b, 16b, 38.

Metallurgy and Ore Dressing 5a, 5b, 6a, 8a, 13a, 17a, 21b, 33a, 33b, 34a, 36b, 38.

Mining 38, 11b, 13a, 15a, 16a, 16b, 18b.

Physics 11a, 11b, 12a, 12b, 15b, 16b, 17b.

Thesis.

The only restrictions on the choice of electives are the prerequisites for studies and the fixed schedule of hours. No conflicts whatever are permitted in the arrangement of the student's schedule. Under the arrangement of the schedule certain combinations of studies are possible, some of which are listed below:

MINING GEOLOGY. *First Semester.* Petrography, Lectures and Laboratory; Geology of the United States, Economic Geology; Field Geology; Ore Dressing; Metallurgy; Mining Machinery; Mining or Metallurgy Laboratory; Compressed Air; Advanced Geology Laboratory.

Second semester. Petrography, Lectures and Laboratory; Geology Conference; Economic Geology; Structural Geology; Ore Dressing, Lectures and Laboratory; Contracts; Mining, Lectures and Laboratory.

GENERAL MINING. *First semester.* Framed Structures and Graphics; Electrical Machinery, Lectures and Laboratory; Ore Dressing, Lectures and Problems; Mining Machinery; Economic Geology; Metallurgy; Metallurgy Laboratory; Metallurgy Conference; and Compressed Air, Lectures and Laboratory.

Second semester. Electrical Machinery, Lectures and Laboratory; Power Plant Design and Laboratory; Ore Dressing, Lectures and Laboratory; Contracts; Mining; Metallurgy, or Economic Geology; Metallurgy Laboratory; Mining Laboratory.

Coal Mining. *First semester.* Framed Structures and Graphics; Electrical Machinery, Lectures and Laboratory; Compressed Air, Lectures and Laboratory; Ore Dressing; Coal Mining; Mining Machinery; Engineering Design; Oil and Gas.

Second semester. Masonry Design and Drawing; Contracts; Electrical Machinery, Lectures and Laboratory; Power Plant Design and Laboratory; Mining; Economic Geology; Oil and Gas, Lectures and Laboratory; Mining Laboratory.

Note: Not over 29 hours' work can be taken each semester.

II. METALLURGY CURRICULUM

The Freshman Year in II. is the same as in I. See page 39.

Department	No.	Course	Page	Hours Per Week		Hours Credit
				Lect.	Lab.	
SOPHOMORE YEAR						
First Semester						
Chemistry	5a	Quantitative Analysis	52	2		2
Chemistry	6a	Quantitative Laboratory	52		6	3
Chemistry	7a	Physical Chemistry	53	2		2
Civil Engineering	2a	Surveying	64		9	5
English	3a	English Prose	73	3		3
Geology and Mineralogy	1a	Mineralogy	79	2	6	5
Modern Languages	7a	German	75			
Modern Languages	9a	French, or	75	3		3
Modern Languages	11a	Spanish	75			
	9a	Differential Calculus	86			
Mathematics	11a	Integral Calculus	86	4		4
Second Semester.						
Chemistry	6b	Quantitative Laboratory	53		9	4.5
Chemistry	7b	Analytical Chemistry	53	2		2
English	3b	English Prose	74	3		3
Geology and Mineralogy	1b	Mineralogy	79	2	6	5
Modern Languages	7b	German	75			
Modern Languages	9b	French, or	75	3		3
Modern Languages	11b	Spanish	75			
Mathematics	11b	Integral Calculus	86			
Mathematics	13b	Differential Equations	86	5		5
Physics	1b	General Physics	112	4		4
Physics	2b	Physics Laboratory	112		3	1.5

II. METALLURGY CURRICULUM

Department	No.	Course.	Page	Hours Per Week		Hours Credit
				Lect.	Lab.	
JUNIOR YEAR						
First Semester						
Chemistry	9a	Electrochemistry	54	2		2
Chemistry	10a	Electrochemistry Lab.*	54		6	3
Chemistry	8a	Quantitative Analysis*	54		6	3
Geology and Mineralogy	3a	General Geology	80	4		4
Geology and Mineralogy	5a	Lithology	81	1	3	2.5
Mathematics	15a	Statics	87	2		2
Mathematics	17a	Mechanics of Materials	87	2		2
Physics	3a	Physics	113	4		4
Physics	4a	Physics Laboratory	113		3	1.5
Physics	5a	Thermodynamics	113	3		3
Physics	6a	Steam Laboratory	113		3	1.5
Second Semester						
Chemistry	11b	Chemical Memoirs	55	2		2
Civil Engineering	9b	Hydraulics	66	3		3
Civil Engineering	10b	Hydraulic Problems	66		3	1.5
Geology and Mineralogy	3b	General Geology	80	4		4
Geology and Mineralogy	4b	Geology Laboratory	80		6	3
Mathematics	19b	Mechanics of Materials	87	2		2
Mathematics	21b	Dynamics	87	2		2
Metallurgy and Ore Dressing	1b	Fire Assaying	90	2		2
Metallurgy and Ore Dressing	2b	Assaying Laboratory	90		9	4.5
Metallurgy and Ore Dressing	2b	General Metallurgy	91	3		3
Metallurgy and Ore Dressing	31b	Elements of Ore Dressing	97	2		2

*Chemistry 8a and Chemistry 10a are alternates: Either one may be chosen.

II. METALLURGY CURRICULUM.

SENIOR YEAR.

The entire Senior year of Curriculum II. is elective. Prerequisites and the fixed schedule of hours for the semesters will govern in the selection of studies. Including three units thesis work, a total of sixty-two units must be completed for the Senior year. The following group of studies is recommended: The Junior trip may be counted as 6 units towards this amount.

First semester. Electro-Metallurgy; Principles and Practice of Electrical Engineering, Lectures and Laboratory; Compressed Air, Lectures and Laboratory; Ore Dressing, Lectures and Laboratory; Alloys, Lectures and Laboratory; Metallurgy Lectures, Problems, Laboratory and Conference.

Second semester. Principles and Practice of Electrical Engineering, Lectures and Laboratory; Contracts; Mining; Ore Dressing, Lectures and Laboratory; Cyaniding; Metallurgy, Lectures and Laboratory Metallurgy Memoirs; Thesis.

The foregoing is planned for the student who wishes to pursue a general course in Metallurgy. Students desiring to specialize in Ore Dressing; Electro-Metallurgy; Metallurgy of Iron and Steel, Metallurgy of Gold; and Metallurgy of Lead or Metallurgy of Zinc; should consult with the Metallurgy Department before arranging the schedule of hours.

III. CIVIL ENGINEERING CURRICULUM

The Freshman Year in III is the same as in I.

Department	No.	Course.	Page	Hours Per Week		Hours Credit
				Lect.	Lab.	
SOPHOMORE YEAR						
First Semester						
Civil Engineering	2a	Plane Surveying	64		9	5
Civil Engineering	5a	Engineering Details	65		6	3
English	3a	English Prose	73	3		3
Modern Languages	7a	German	75			
Modern Languages	9a	French, or	75	3		3
Modern Languages	11a	Spanish	75			
Mathematics	9a	Differential Calculus	86			
Mathematics	11a	Integral Calculus	86	4		4
Physics	3a	Physics	113	4		4
Physics	4a	Physics Laboratory	113		3	1.5
Mining	3a	Mining	104	3		3
Second Semester.						
Civil Engineering	3b	Higher Surveying	65		12	6
English	3b	English Prose	74	2		2
Geology and Mineralogy	2b	Mineralogy	79		3	2
Modern Languages	7b	German	75			
Modern Languages	9b	French, or	75	3		3
Modern Languages	11b	Spanish	75			
Mathematics	11b	Integral Calculus	86			
Mathematics	13b	Differential Equations	86	5		5
Mathematics	15a	Statics	87			
Mathematics	17a	Mechanics of Materials	87	4		4
Physics	1b	General Physics	112	4		4
Physics	2b	Physics Laboratory	112		3	1.5

III. CIVIL ENGINEERING CURRICULUM

Department	No.	Course	Page	Hours Per Week		Hours Credit
				Lect.	Lab.	
JUNIOR YEAR.						
First Semester.						
Civil Engineering	7a	Railroad Surveying	66	2	3	3.5
Civil Engineering	12a	Foundations	67	2	6	5
Geology and Mineralogy	3a	General Geology	80	4		4
Mathematics	21b	Dynamics	87			
Mathematics	19b	Mechanics of Materials	87	4		4
Civil Engineering	20a	Concrete Laboratory	69			
		Materials Laboratory	69		6	3
Physics	5a	Thermodynamics	113	3		3
Physics	6a	Steam Laboratory	113		3	1.5
		Electives		3		3
Second Semester						
Civil Engineering	9b	Hydraulics	66	3	3	4.5
Civil Engineering	12b	Beams and Arches	68	2	6	5
Civil Engineering	13b	Roads and Pavements	68	3		3
Civil Engineering	14b	Stresses	68	2	6	5
Geology and Mineralogy	6b	Geology Laboratory	81		3	1.5
Metallurgy and Ore Dressing	3b	Civil Engineering Metallurgy	91	3		3
		Electives		5		5
SENIOR YEAR						
First Year						
Civil Engineering	15a	Frame Structures	69	2		2
Civil Engineering	16a	Engineering Design	69		9	4.5
Civil Engineering	19a	Water Supply	69	5		5
		Electives		10	6	13
Second Semester.						
Civil Engineering	17b	Contracts	69	1		1
Civil Engineering	25b	Bridges	71	5		5
Civil Engineering	29b	Sanitary Engineering	72	5		5
Civil Engineering	31b	Masonry Design	72	3		3
Civil Engineering	32b	Masonry Design Practice	72		3	1.5
		Electives		3	6	8
		Thesis			6	3

IV. GENERAL SCIENCE CURRICULUM*

The Freshman Year in IV is the same as in I. See page 39.

Department	No.	Course	Page	Hours Per Week		Hours Credit
				Lect.	Lab.	
SOPHOMORE YEAR						
First Semester						
English	3a	English Prose	73	3		3
Modern Languages		Modern Languages	74	6		6
		Electives		10	18	19
Second Semester						
English	3b	English Prose	73	3		3
Modern Languages		Modern Languages	74	6		6
		Electives		10	18	19
JUNIOR YEAR						
First Semester						
English	5a	18th Century Prose	74	3		3
Modern Languages		Modern Languages	74	6		6
		Electives		10	18	19
Second Semester						
English	5b	Shakespeare	74	3		3
Modern Languages		Modern Languages	74	6		6
		Electives		10	18	19

In addition to the requirements mentioned above, seven (7) hours of recitations must be elected in the Sophomore and the Junior years from Chemistry, Geology, Mathematics, or Physics, separately or collectively, at the option of the Student and with the approval of the faculty. Three (3) hours of recitations may be elected in these years from any regularly catalogued course for which the student is prepared.

SENIOR YEAR.

Subjects All Elective.—Nineteen hours of recitation and eighteen hours of laboratory work must be elected each semester. In the second semester six hours a week thesis work is to be included in the laboratory time.

All electives throughout the course must be chosen, with the approval of the faculty, from one of the following groups:

Physics-Mathematics, Chemistry-Mathematics, Physics-Chemistry-Mathematics, Chemistry-Metallurgy, Chemistry-Geology, Geology-Mining, Mining-Metallurgy.

*Candidates for degress in Curriculum IV are required to complete four semesters' work in each of any two modern languages offered, namely, French, German, and Spanish.

Candidates for degrees in General Science must matriculate in the General Science Curriculum not later than the beginning of the Junior year.

V. GRADUATE CURRICULUM IN MINE ENGINEERING.

Graduates of this or other institutions of equal rank who have received the degree of Bachelor of Science in Mine Engineering may matriculate for a course of graduate study and research in Mine Engineering. The minimum requirement is the completion of fifty-six units work including a thesis.

Candidates for degrees must give half their time to work upon a major subject which must be in the Department of Mining, Geology, or Metallurgy and Ore Dressing. At least one-fourth of the work must be done in one of the other departments noted above. The major and the minor subjects must be approved by the Faculty before the student enters upon the work. A suitable thesis subject must be approved.

V. GRADUATE CURRICULUM IN METALLURGY.

Graduates of this school or of other institutions of equal rank who have completed a course of study leading to the degree of Bachelor of Science in Metallurgy may undertake advanced work leading to the degree of Metallurgical Engineer. The minimum requirement is fifty-six units work including a thesis.

Candidates for the degree of Metallurgical Engineer must give half their time to work upon a major subject in the Department of Metallurgy and Ore Dressing. At least fourteen units work shall be upon a minor subject in another department. The major, the minor, and the thesis subjects must be approved by the faculty.

VII. GRADUATE CURRICULUM FOR ENGINEERS.

Graduates in Civil, Electrical, and Mechanical Engineering may become candidates for the degree of Engineer of Mines upon the completion of two years' work (112 units), in residence at this institution.

The student will be required to complete or to present credits for all of the subjects outlined for the first three years of the course in Mine Engineering and will be expected to earn or present credits in a total of one hundred twelve units above the Junior year, and take all of the trips required in the Mine Engineering Curriculum.

Attention is directed to the list of studies on page 34. Work will be arranged in Mine Engineering, Metallurgy, Ore Dressing, and Geology for students who desire to specialize along some particular line. Research work must be carried on during the second year and a thesis must be submitted.

CHEMISTRY

Professor Gottschalk, Mr. Ingram, Mr. Neal, Mr. Lane, Mr. Johnson, Mr. Grotts.

Equipment.

One entire building is devoted to chemistry. The main chemical lecture room occupies the entire south wing of the building. The laboratories for general chemistry and for qualitative analysis, on the first floor of the main building, accommodate together about one hundred forty students. The quantitative laboratories on the second floor have desk room for seventy-five students working at one time. In the north wing is a smaller lecture room, as well as a capacious laboratory for advanced students.

Excellent ventilation is provided by a thirteen-horsepower motor and suction fan connected with individual hoods over each laboratory desk and with the long lines of fume chambers distributed throughout the building. Gas, water, and air blast are supplied conveniently, while a steam-heated still of five gallons an hour capacity furnishes ample distilled water.

The equipment includes twenty-four first-class analytical balances, sixty sets of good analytical weights, sixty sets of volumetric instruments with Bureau of Standards stamps, several complete sets of gas analysis apparatus, standard instruments for the physical and chemical testing of petroleum and its products, a liberal supply of platinum ware, and a good selection of precision instruments for physico-chemical and electro-chemical measurements.

The department has secured the co-operation of some of the chemical manufacturing concerns and is preparing for exhibition a Museum of Industrial Chemistry. Exhibits of the raw material and products illustrating the processes in many of the industries have already been received and are being arranged for display.

The appropriation made for equipping an Industrial Laboratory will provide adequate machinery and accessories to erect, in the north wing of the Chemical Building, a number of complete miniature industrial works. The machines installed will probably include a double effect evaporator, vacuum pan, steam kettles, mixing machines, filter presses, apparatus for distillation and rectification, grinding machinery, and the incidentals necessary for the preparation of commercial chemicals, soap, paints, dyed textiles, wood products, acids, oils, leather.

CHEMISTRY BUILDING

CAMPUS VIEW

With the proposed rearrangement of the building more space will be available for laboratory work in organic, physical, and electro-chemistry, as well as in the applied chemistry.

Courses.

1a. GENERAL CHEMISTRY. *Lectures.* (Ingram)

This course is a comprehensive study of the general principles of chemistry and of the more important non-metals. The fundamental laws of chemistry are developed in logical order, special attention being given to their application in practical computations. Carefully designed lecture experiments are a feature of the course. The class is divided into several smaller sections for recitation and discussion of problems.

Prerequisites: Entrance requirements.

Required in I., II., III., and IV.

Freshmen year, first semester, five hours per week. Credit five hours.

Text: McPherson and Henderson, *A Course in General Chemistry.*

Chauvenet, *Chemical Arithmetic and Furnace Charges.*

1b. GENERAL CHEMISTRY. *Lectures.* (Ingram)

Continuation of course 1a; devoted to the chemistry of the metals, with special consideration of the reactions employed in analytical chemistry, in metallurgy, and in geology. The ionic theory, phase rule, and mass-law are introduced, and applied at advantageous points in the lectures.

The course concludes with a series of lectures on elementary applied chemistry.

Prerequisites: Chemistry 1a and 2a.

Required in I., II., III., and IV.

Freshman year, second semester, five hours per week. Credit five hours.

Text: Same as in 1a.

2a. GENERAL CHEMISTRY. *Laboratory.*
(Ingram, Johnson, Grotts)

The laboratory work accompanying general chemistry consists of experiments which are largely quantitative, and which are intended to teach stoichiometrical relations from the first.

Prerequisite. Must be accompanied by Chemistry 1a.

Required in I., II., III., and IV.

Freshman year, first semester, six hours per week. Credit three hours.

Text: C. M. Allen, *Exercises in General Chemistry.*

3b. QUALITATIVE ANALYSIS. *Lectures.* (Ingram)

This course is an exposition of the principles underlying the qualitative separation and identification of the commoner elements found in minerals, rocks, and metallurgical products.

Prerequisites: Chemistry 1a and 2a and accompanied by 1b.

Required in I., II., III., and IV.

Freshman year, second semester, two hours per week. Credit two hours.

Text: A. A. Noyes, *Qualitative Analysis.*
Manuscript Notes.

4b. QUALITATIVE ANALYSIS. *Laboratory.*
(Ingram, Johnson, Grotts)

The student is drilled in the practical separation and identification of ordinary mineral constituents, the examples for practice consisting of solutions, mixtures of salts, alloys and ores. Wet methods are followed entirely with the exception of a few tests by means of the spectroscope.

Prerequisite: Chemistry 2a, and must be accompanied by 3b.

Required in I., II., III., and IV.

Freshman year, second semester six hours a week. Credit three hours.

Text: A. A. Noyes, *Qualitative Analysis.*
Manuscript Notes.

5a. QUANTITATIVE ANALYSIS. *Lectures.* (Gottschalk)

The subjects discussed in this course are as follows: The balance, weights, and the process of weighing; simple gravimetric analysis; analysis of silicate rocks, and application to clay, shale, and slag analysis; volumetric instruments, their calibration and use; volumetric analysis, standard solutions, indicators; technical volumetric methods in general, wet assaying of copper, zinc, and lead ores and concentrates. Problems in the calculations of analytical chemistry are also discussed.

Prerequisites: Chemistry 3b, 4b.

Required in I., and II.

Sophomore year, first semester, two hours per week. Credit two hours.

Text: *Manuscript Notes.*
Miller, *Calculations of Analytical Chemistry.*

6a. QUANTITATIVE ANALYSIS. *Laboratory.*
(Gottschalk, Neal)

Before beginning actual quantitative analysis, the student is required to make a careful study of the balance and of the meth-

od of weighing. The rest of the time is given to exercises in simple gravimetric analysis, with some volumetric analysis, chiefly on analyzed mixtures, closing with a (technical) clay analysis.

Prerequisites: Chemistry 3b, 4b, and must be accompanied by 5a.

Required in I., and II.

Sophomore year, first semester, six hours per week. Credit three hours.

Text: Moody, *Quantitative Analysis.*

6b. QUANTITATIVE ANALYSIS. *Laboratory.*
(Gottschalk, Neal)

Technical methods for the determination of copper, lead, zinc, arsenic, antimony, sulphur, and coal analysis. Essential parts of the course are the speed tests, in which students are required to report correct results on a number of copper, zinc, and lead ores within a stated time.

Actual ores, analyzed by the instructing staff, are on hand in quantity, and the students are trained to attain the same degree of accuracy which obtains in smelter laboratories.

Prerequisite: Chemistry 6a.

Required in I., and II.

Sophomore year, second semester, nine hours per week. Credit 4.5 hours. Six hours per week for students in curriculum I. Credit 3 hours.

Text Seamon, *Manual for Assayers and Chemists.*
Low, *Ore Analysis.*

7a. PHYSICAL CHEMISTRY. *Lectures.* (Gottschalk)

This course is intended as an introduction to physical chemistry. The qualitative and quantitative theories of chemical equilibria as given by the phase rule and by the mass law are studied first. Towards the end of the term the basis of the ionic theory is discussed.

Prerequisite: Chemistry 4b.

Required in II.

Sophomore year, first semester, two hours per week. Credit two hours.

7b. ANALYTICAL CHEMISTRY. *Lectures.* (Gottschalk)

The application of the ionic theory to analytical chemistry is taken up in detail; a select number of lecture experiments illustrate the main propositions advanced.

Prerequisite: Chemistry 7a.

Required in II.

Sophomore year, second semester, two hours per week. Credit two hours.

Text: Stieglitz, *Qualitative Analysis, Part I.*

8a. QUANTITATIVE ANALYSIS. *Laboratory.*

(Gottschalk)

This course is offered primarily for students of metallurgy who desire to become acquainted with the methods of analysis of matters, speisses, crude and refined lead and copper bullion, spelter, alloys, and similar material. No required schedule is laid out; students are strongly recommended to employ some of this time in elementary physico-chemical measurements, as this subject has become nearly indispensable in their branch.

Prerequisite: Chemistry 6b.

Required in II, as alternate with 10a.

Junior year, first semester, six hours per week. Credit three hours.

8b. QUANTITATIVE ANALYSIS. *Laboratory.*

(Gottschalk)

General methods in industrial analysis, the course being designed to illustrate principles, with the intention of developing the ability to select methods, and to adapt them when occasion demands.

Prerequisites: Chemistry 6a, 21a.

Required in VI.

Sophomore year, second semester, two afternoons per week. Credit three hours.

9a. ELECTRO-CHEMISTRY. *Lectures.* (Gottschalk)

The course opens with a brief theoretical introduction to the Nernst theory. The main object of the lectures is the application to the theory of the deposition of metals out of aqueous solutions as practiced in electro-metallurgy.

Prerequisite: Chemistry 7b.

Required in II.

Junior year, first semester, two lectures per week. Credit two hours.

Text: *Manuscript Notes.*

10a. ELECTRO-CHEMISTRY. *Laboratory.* (Gottschalk)

The practical work consists of the measurements of electrolytic conductances and of single differences of potential, followed by experiments on the relation between the electrode potential and current density, and on the electrolytic refining of metals.

Prerequisite: Must be accompanied by Chemistry 9a.

Required in II., as alternate with 8a.

Junior year, first semester, six hours per week. Credit three hours.

Text: *Manuscript Notes.*

11a. MEMOIRS. *Class-room Work.* (Gottschalk, Ingram)

Similar to 11b, somewhat more advanced and subjects selected to suit.

Prerequisites: 2b, 21a.

11b. CHEMICAL MEMOIRS. *Classroom Work.*

(Gottschalk)

Carefully prepared abstracts of current articles or of special subjects are prepared by the student for this course.

Prerequisite: Chemistry 9a.

Required in II.

Junior year, second semester, two hours per week. Credit two hours.

Elective and Graduate Courses.

12b. WALTER ANALYSIS. *Laboratory.*

This course is designed to meet the wants of engineering students. Sanitary water analysis and boiler water analysis are offered, although students interested in geology may substitute mineral water analysis for some of the work.

Prerequisite: Chemistry 6a.

Elective, second semester, six hours per week. Credit three hours.

13a. THEORETICAL CHEMISTRY. *Lectures.* (Gottschalk)

The applications of theoretical chemistry to fundamental metallurgical principles are assuming such prominence and leading to such important results that a knowledge of this subject is indispensable to the metallurgical engineer who desires to keep pace with the developments in this field. To meet this demand a course for graduate students is offered, presenting the subject of chemical equilibria from the thermodynamic point of view, including a consideration of the technical applications made by Nernst, Le Chatelier, Haber, von Jueptner and others. The student is expected to do considerable reading of original articles in English, German and French scientific journals and books.

Prerequisites: Chemistry 9a, Mathematics 15a and 17a, and Physics 5a.

Graduate course, first semester, two lectures per week. Credit two hours.

13b. THEORETICAL CHEMISTRY. *Lectures.* (Gottschalk)

Continuation of Chemistry 13a.

Second semester, two lectures per week. Credit two hours.

Reference: Nernst, *Theoretical Chemistry.*

14b. ADVANCED CHEMISTRY. *Laboratory.* (Gottschalk)

This is an advanced course to accompany the lectures in Theoretical Chemistry, and includes the study and measurements of typical chemical equilibria, either as a repetition of classical researches in this field, or preferably on original problems. The equipment for this work includes measuring instruments of the most approved types for high temperature, electro-thermic and physico-chemical work, and special apparatus built in the school shops.

Prerequisite: Must be accompanied by Chemistry 13b.

Second semester, six hours per week. Credit three hours.

15a. ENGINEERING CHEMISTRY. *Lectures.* (Ingram)

There is nothing more essential to the practical engineer of today, no matter in which of the special branches he is working, than an intimate knowledge of the chemistry as well as the mechanics of materials. In this course are taken up in order the chemistry of fuels, industrial waters, lubricants, building materials, lime and cement paving and wood preservation paints and varnishes, and explosives.

One hour per week is devoted to reports by the students on topics of interest gleaned from the industrial journals.

Prerequisites: Chemistry 5a, 6a, and 6b.

First semester, three hours per week. Credit three hours.

Text: Benson, *Industrial Chemistry.*
Manuscript Notes.

16a. INDUSTRIAL CHEMISTRY. *Plant.*
(Ingram, Grotts, Johnson)

This course is designed to accompany the lectures in Industrial Chemistry and to give the student an opportunity to revise his pre-acquired knowledge to fit large-scale operations. It is purposed that the chemical engineers should at this point in their course be required to demonstrate their ability in putting to practical use in the works those principles of chemistry and mechanical and electrical engineering which they may have learned in the more or less preparatory courses.

A detailed description of the plant with all its machinery and accessories cannot be given as yet, since all of the equipment has not been definitely decided on. It is the intention, however, to equip this laboratory as completely as possible with most of the appliances necessary for large-scale operations. The plant will be arranged to illustrate the methods used in commercial chemical works, and the actual working of each process will be in charge of a superintendent appointed from among the students. This man is to be solely responsible for the success or failure of

the work under his direction, and each man in the course must occupy this position in turn. The other students are to be arranged into a working force suitable to the process in hand.

The actual manufacture of some of the materials studied in Chemistry 16a is to be carried out, special attention being paid to yields and cost of manufacture.

During the term 1915-1916 the work will consist of assisting in the erection and testing of the various types of machinery. Full credit will be given for this work.

This course must be accompanied by Chemistry 17a.

Prerequisites: Chemistry 8b, 23b.

Senior year, first semester, six hours per week. Credit three hours.

Text: Rogers, *Laboratory Guide of Industrial Chemistry.*
Manuscript Notes and Blue Prints.
Reference Works.

16b. INDUSTRIAL CHEMISTRY. *Plant.* (Ingram)

While not necessarily a continuation of Chemistry 17a, the work undertaken in this course may be made similar to that of the above if the student should so desire. The work is open, more or less, to the election of the student. The following specialties may be elected:

Design of Chemical Plants.
Chemical Machine Design.
Process Investigation.
Chemical Cost Data.
Process Evolution.

To be accompanied by Chemistry 17b.

Prerequisite: Chemistry 6a.

Senior year, second semester, six hours per week. Credit three hours.

17a. INDUSTRIAL CHEMISTRY. *Lectures.* (Ingram)

This is essentially an advanced course in Applied Chemistry. As considerable time is spent in the course in General Chemistry in discussing its application in the industries, a certain elementary knowledge of the subject is presupposed.

No attempt is made to burden the student with the usual mass of detail concerning the various standard processes, although a certain amount of textbook work is required. The application of physico-chemical methods to the solution of practical industrial problems is consdered of primary importance and receives the maximum amount of attention. The theories underlying the more typical industrial operations are taken up, some time being devoted to discussions on drying, evaporation, crystallization, filtration, heat-transfer, distillation, etc.

The specific industries studied are selected more for the typical operations they involve rather than in an attempt to cover the entire field. The selections may be made from the following, and may vary from year to year: The Acid Industrials, Ammonia and Alkali, Fertilizers, Commercial Chemicals Distillation of Coal and Wood, Soaps, Oil Industries, Sugar and Glucose, Paper, Industrial Alcohol, Laundering, Textiles and Dyeing, Leather, etc.

Prerequisites: Chemistry 20b, 23b.

This course must be accompanied by Chemistry 16a.

Senior year, first semester, four hours per week. Credit four hours.

Text: Rogers, *Industrial Chemistry.*
Kremann-Potts, *Applications of Physico-Chemical Theory.*
Manuscript Notes.
Reference.

17b. INDUSTRIAL CHEMISTRY. *Lectures.* (Ingram)

A continuation of course 16a, together with a consideration of the design, erection and equipment of chemical plants.

Prerequisite: Chemistry 16a.

This course must be accompanied by Chemistry 16b.

Senior year, second semester, two hours per week. Credit two hours.

Text and Reference: Dyson and Clarkson, *Chemical Works, Their Design, Erection and Equipment.*
Manuscript Notes and Blue Prints.

18a. PHYSICAL CHEMISTRY. *Laboratory.* (Gottschalk)

While some attention is paid to the application of physical methods to chemistry, the special stress in this course is laid on the study of the effects of the equilibrium factors on chemical reactions.

Prerequisites: Chemistry 4b and accompanied by 7a.

Junior year, first semester, three afternoons per week. Credit three hours.

Text: Findlay, *Practical Physical Chemistry.*

20b. PREPARATIONS: ORGANIC AND INORGANIC. (Gottschalk, Ingram)

In order to assist the man in gaining a certain amount of chemical technique not attained by ordinary quantitative manipulation, this work in the preparation of some of the more difficult organic and inorganic substances is offered. This course will supplement the work in quantitative analysis, as determinations of the purity of the substances prepared will be required.

Beside the ordinary preparations described in the texts it will be necessary for those pursuing this course to select and prepare at least one rather rare specimen for the chemical museum. Much attention is paid to yields and purity of products.

Prerequisite: Chemistry 22a.

Sophomore year, second semester, six hours per week. Credit three hours.

Texts: Thorp, *Inorganic Preparations.*
Blanchard, *Synthetic Inorganic Chemistry.*
Gatterman, *Practical Methods of Organic Chemistry.*
Rogers, *Laboratory Guide of Industrial Chemistry.*

21a. ORGANIC CHEMISTRY. *Lectures.* (Gottschalk)

A brief, elementary course, giving the foundation for further study.

Prerequisites: Chemistry 1b, 2b.

Sophomore year, first semester, two times a week. Credit two hours.

Text: W. A. Noyes, *Organic Chemistry.*

22a. ORGANIC CHEMISTRY. *Laboratory.* (Gottschalk)

To supplement 21a. The student will be required to spend considerable time in the library, in addition to the time spent in the laboratory.

Prerequisites: Must be accompanied by Chemistry 21a.

Sophomore year, first semester, two afternoons per week. Credit three hours.

Text: Gattermann, *Practical Methods of Organic Chemistry.*

23b. INDUSTRIAL ECONOMICS. *Lectures.* (Ingram)

Before passing on to the consideration of the specific industries, which is taken up in the Senior year, the men are first introduced to some of the economic and administrative problems involved in chemical manufacturing. To begin with, this necessitates a rather extended reading course in Pure Political Economy, which is to serve as a foundation for subsequent application to Industrial problems.

While the student is acquiring this economic perspective, the subjects of Business Administration, which includes Accounting Systems, Purchasing, Selling, etc., Patents, Industrial Organization, Professional Ethics, Factory Hygiene and Scientific Management are discussed. The latter part of the course consists of lectures in and reading assignments on the following topics: Effect of Economic Conditions on Location of Chemical Plants, Price and Value of Products, Markets and Transportation, Labor, Legislation relating to the Use and Manufacture of Chemicals, In-

dustrial Insurance, Competition, Exports and Imports and the Exploitation of Chemical Ideas.

Prerequisites: Chemistry 20b and 15a.

To be accompanied by Chemistry 24b.

Junior year, second semester, three hours per week. Credit three hours.

Texts: *Manuscript Notes.*
Manuscript Translations.
Reference Works.

24b. CHEMICAL ENGINEERING DATA. *Laboratory.* (Ingram)

To accompany and supplement the work described in Chemistry 23b. To consist mainly of individual research in the collection and compilation of data concerning the administrative as well as the scientific side of Chemical Manufacturing. An attempt is made to gain some insight into the manner in which the office collects, files and interprets the facts and figures furnished by the works. Graphical methods of presentation of the information gathered are studied, and cost, efficiency and valuation curves constructed from data furnished by the industries.

Prerequisite: To be accompanied by Chemistry 23b.

Junior year, second semester, three hours per week. Credit three hours.

25b. APPLIED ELECTRO-CHEMISTRY. *Lectures.* (Gottschalk)

Discuss the industrial electro-chemical processes (not including refining of metals).

Prerequisites: Chemistry 18a, 22a. Physics 4a.

Junior year, second semester, two lectures per week. Credit two hours.

Text: Allman, *Electro-chemistry.*

26b. APPLIED ELECTRO-CHEMISTRY. *Laboratory.* (Gottschalk)

Electrochemical preparations, electrolytic reduction and oxidation, calculations of costs, study of conditions of production.

Prerequisites: Must be accompanied by 25b.

Junior year, second semester, two afternoons per week. Credit three hours.

27b. OIL AND GAS. *Lectures.* (Ingram)

In the introductory lectures is taken up a consideration of the hydrocarbons and other carbon compounds found in crude petroleum. This is followed by a classification of oils according to

chemical characteristics. The chemical and physical tests of crude and refined oils are then discussed and compared, and this part of the work completed with a study of the various steps in certain refining processes.

The different methods of technical gas analysis are next taken up with special reference as to their adaptability to industrial control work. A small amount of the physics of gases and gas mixtures is here introduced.

Prerequisite: Chemistry.

Senior elective.

Senior year, second semester, two hours per week. Credit two hours.

28b. OIL AND GAS. *Laboratory.* (Ingram and Assistants)

To accompany Chemistry 27b.

Materials and apparatus are furnished for the complete testing of crude and refined oils and asphalts. An effort is made to secure crude oil samples which will be of value to the geologist specializing in Oil and Gas. On most of these samples, the District, Depth of Well and Oil-bearing Formation is known. The laboratory is equipped with many of the standard instruments for making practical tests.

The Chemical Engineers will devote most of their time to Gas Analysis and will be required to handle both the Hemple and Orsat schemes.

Prerequisite: To be accompanied by Chemistry 27b.

Senior elective.

Senior year, second semester, six hours per week. Credit three hours.

29b. SEMINAR. *Class-room Work.* (Gottschalk, Ingram)

Prerequisites: Chemistry 11a, 17a.

Senior year, second semester, two meetings a week. Credit two hours.

CIVIL ENGINEERING

Professor Harris, Assistant Professor McCandliss, Mr. Risher, Mr. Ashdown, Mr. Blaylock, Mr. Sailer, Mr. Gannon.

The Department of Civil Engineering has its lecture rooms, drafting rooms, offices and department library in Norwood Hall. The compressed air and hydraulics laboratories, and the locker rooms for field equipment, are in the Power Plant Building.

The plan of study is designed to afford such theoretical and practical training that the graduates will be prepared to perform at once the minor duties in the various branches of the profession. Especial stress is laid upon proficiency in field work, drafting and design of engineering structures.

For field work the department is equipped with twenty-one transits, five of which are complete mining instruments with side and top telescopes, and fourteen wye and dumpy levels, representing the principal makes and types of construction. Additional equipment includes a solar compass, a surveyor's compass, three geologist's compasses, four Brunten transits, twelve plane tables, including a Johnson's plane table with telescopic alidade, two sextants, and a liberal supply of hand levels, barometers, clinometers, dip needles, angle prisms, chains, tapes, level rods, stadia rods, range poles, etc.

The field work is so outlined that the student has an opportunity to judge the relative merits of the various types of field instruments.

An important feature of the instrument room is the locker system. Due to the scope of the equipment it has been possible to arrange in separate lockers complete equipment for each surveying squad.

For the hydrographic field work the department is liberally equipped with current meters, gauges, floats, etc.

The hydrographic field work is not outlined with the regularly catalogued courses but is given, as a special course for Seniors in the School of Civil Engineering. The work is usually conducted on the Gasconade river.

The department has at its disposal, well lighted and ventilated drafting rooms, which are equipped with filing cases, drafting tables, desks, etc., and facilities for making prints.

An important feature of the drafting room used for surveying and topographic drawing is the manner of illuminating the drafting tables on cloudy days. This is accomplished by the use of individual electric lights.

TESTING MACHINERY—MATERIALS LABORATORY

CORNER IN C. E. DRAWING ROOM

Especial attention has been given to the design of apparatus for research work in problems relating to the handling of air under varying pressures. In this equipment are two compound air compressors, two steel tanks of 300 cubic feet capacity each (tested to 125 pounds pressure) for measuring air by direct displacement with water, one Sullivan displacement air meter, one mechanical air meter, three orific drums, two differential gauges and all necessary appurtenances, such as pressure gauges, thermometers, etc.

For experimental research with air at low pressures as in fans and blowers, the laboratory is equipped with a Sirrocco fan, having a capacity of 30,000 cubic feet per minute at 6 inches water gauge. The fan discharges through a conduit which is arranged especially for inserting orifices, anamometers, Pilot tubes and similar devices into the current of air.

The fan is propelled by a variable speed motor which thus affords a wide field for experimentation.

With this apparatus coefficients are being determined for orifices, in metal plates, ranging from 1-16 inch to 30 inches in diameter.

The Laboratory for Testing Materials and the Cement Testing Laboratory, together with office, supply and computation rooms, occupy almost the entire ground floor of Parker Hall, and constitute the Engineering Laboratories.

The function of these laboratories is to give to the student an experimental knowledge of the physical characteristics of normal and defective materials of construction and of their behaviour under stress, to verify the fundamental assumptions underlying the laws of mechanics, and to experimentally set forth the application and the limitations of such laws, as used in engineering, and to afford training in the methods of conducting experimental work, as well as the presentation of the fact of such investigations in clear, concise and conclusive engineering reports. The laboratories afford facilities for research in the design and the methods of failure of structures, the study of the physical characteristics and composition of materials, and the determination of the laws controlling the behavior of stressed and unstressed members.

The laboratory for testing materials is situated in the east wing of the building, having a floor area of some 2,500 sq. ft. The laboratory is equipped with one 200,000 pound capacity universal testing machine of the Olsen type, which is capable of testing specimens eight feet long in either tension or compression, and specimens in cross bending 16 ft. long between supports. It also contains two machines, each of 50,000 pound capacity, of the Riehle type, which are used for testing small specimens in tension compression and cross-bending; one 60,000 inch-pound capacity torsion machine of the Olsen type, and one machine used for

demonstration of the action of levers, and for testing small specimens in cross bendings. All machines in this laboratory are direct connected motor driven. The necessary small equipment, such as extensometers, compressometers, etc., is ample for the needs of the classes, and comprises only the most modern types of instruments.

The cement testing laboratory is located in the northeast wing, of the basement of Parker Hall. This laboratory is equipped with making complete physical tests of cement, concrete and concrete aggregates, and for investigations of the proper proportioning of concrete. The equipment consists of one standard tension testing machine, of the Riehle automatic shot type; one Vicat apparatus; several specific gravity apparatus; one electric drying oven; one standard steamer; an autoclave; a moist closet; apparatus for determination of specific gravity of, and voids in, concrete aggregate; several sets of standard sieves; standard cylindrical molds for concrete; and an ample supply of standard tension briquette molds, graduates, trowels, spatulas and other small apparatus.

This laboratory is further equipped with concrete tables having individual lockers for student use, accommodating twenty-four men; concrete storage bins for cement and aggregates and a concrete storage tank for storing specimens under water.

In order that the experimental work carried on in the Engineering Laboratories may be written up in the form of reports, a computation room has been fitted up. This is a large, well-lighted room, and is so removed from the laboratories proper so that the student is not molested in his work by the noise of the testing machines. This room is also to be used as a museum for displaying materials used in connection with the Engineering Laboratories, both normal and ruptured speciments being displayed. It is also used to display a number of road models, patterned to set forth the approved methods of road construction.

Supply Room.—The supply room is maintained in connection with the laboratories to provide a suitable storage room for the small apparatus used in connection with the tests made. It is also provided with filing cabinets for the purpose of filing reports, data sheets and specimens.

Courses.

2a. SURVEYING. *Plane Surveying.*
(McCandliss, Risher, Ashdown, Gannon)

A general course in surveying, including the adjustments, uses, and limitations of transits, levels, and the minor instruments. Students are drilled in traversing, computing areas, establishing meridians, topographic methods, triangulating, and precise leveling.

The field work is conducted on and about the campus, the work being referenced to stations of a triangulation system, the bearings and lengths of the sides of which have been accurately determined, thus affording a check on the student work.

Prerequisites: Mathematics 1a, 3a.

Required in I., II., and III.

Sophomore year, first semester, three afternoons per week. Credit five hours.

Texts: Pence & Ketchum, *Surveying Manual.*
Johnson and Smith, *Theory and Practice of Surveying.*

3b. SURVEYING. *Higher Surveying.*
(McCandliss Risher, Ashdown, Gannon)

A course embracing descriptive astronomy, with special attention to the determination of azimuth, altitude, latitude, longitude and time; and the theory of base line measurements, precise triangulation, and topography.

Field work and problems are given to accompany the lectures, including the execution of a complete topographic survey and map of a small area; in this work an effort is made to familiarize the students with the various instruments and methods used in topographic surveying.

Prerequisite: Civil Engineering 2a.

Required in III.

Sophomore year, second semester, four afternoons per week. Credit six units.

4. SURVEYING. *Topography.*
(Harris, McCandliss, Risher, Ashdown, Gannon)

An effort is made in this course to execute a complete topographical survey of a small area in the Ozark Mountains, presenting a wide range of conditions, in which practice is afforded in the methods applicable to such work, employing the use of the stadia, plane table and other instruments in so far as the time will permit.

Prerequisite: Civil Engineering 2a.

Required in I.

Summer vacation, one week preceding first semester, Junior year. Credit 1.5 hours.

5a. ENGINEERING DETAILS. *Laboratory.*
(McCandliss, Sailer, Blaylock)

This course is designed to represent the conditions of actual practice in office and drafting room. Especial stress is laid on neatness, accuracy and dispatch. The course covers practice in free-hand lettering for titles, etc., topographical signs, platting of

topographical maps, and the drafting of engineering structures.

Prerequisites: Shop Practice and Drawing 2b.

Required in III.

Sophomore year, first semester, two afternoons per week. Credit three hours.

7a and 8a. SURVEYING. *Railroad Surveying. Lectures.* (McCandliss)

This course treats of the theory, and the practice of surveying, appertaining to the location, construction and maintenance of railroads.

The scope of the work is designed to acquaint the student, in lectures, with the theory of simple, compound, and reversed curves; spirals, frogs, switches, turnouts and cross-overs; earthwork, haul and overhaul; and estimates of quantities. In the afternoon period the student is drilled in the solution of problems.

Prerequisite: Civil Engineering 1a.

Required in I. and III.

Junior year first semester, two lecture hours and one afternoon per week. Credit three and one-half hours.

Text: Allen, *Railroad Curves and Earthwork.*

9b. HYDRAULICS. *Lectures and Problems.* (Harris)

The theory of hydrostatics and of hydraulics and application to the dependent problems in engineering practice, such as the determination of empirical co-efficients and their application in determining the flow of water through orifices, weirs, pipes, canals, and rivers. Also the theory of hydraulic motors and dynamic pumps and the practice with such machines.

One afternoon per week is assigned to the solution of problems in hydraulics and hydrostatics under the direction of the instructor. This includes the testing of the hydraulic equipment of the school.

Prerequisite: Mathematics 15a.

Required in I., II., and III.

Junior year, second semester, three hours per week. Lectures and one afternoon for solution of problems.

Credit 4.5 hours.

Text: Merriman, *Hydraulics.*

10b. HYDRAULIC PROBLEMS. *Laboratory.* (Harris)

One afternoon per week is assigned to the solution of problems in hydraulics and hydrostatics under the direction of the instructor. This includes the testing of the hydraulic equipment of the school, including the air-lift pump.

Prerequisite: To accompany Civil Engineering 9b.

Required in I., II., and III.

Junior year, second semester, one afternoon per week. Credit 1·5 hours.

11b. MASONRY CONSTRUCTION. *Lectures.*

(McCandliss)

This course is designed to cover in lectures the economic use of the more common materials of Masonry Construction. The composition and preparation of limes, cements and clay products are discussed. The laws governing the manufacture and proportionment of concretes and mortars, together with the principles and practice of plain and reinforced concrete construction are treated.

Throughout the course, appropriate problems in the design of simple structures are given the student for solution. This is not a substitute for Civil Engineering 12a or 12b.

Prerequisites: Mineralogy 1a, 1b, Mathematics 15a, 17a, to be accompanied by Mathematics 19b.

Required in I.

Junior year, second semester, two hours per week. Credit two hours.

Text: Baker, *Masonry Construction.*

12a. FOUNDATIONS. *Lectures and Laboratory.*

(McCandliss)

The object of this course is to set forth in lectures the principles governing the theoretical and practical design of the foundations of Engineering Structures. The economics of building materials, and the treatment of ordinary and pile foundations, cofferdams and open well methods, together with the operation of pneumatic caissons, are successively considered. The theory of spread foundations, underpinning of buildings, and the design of gravity dams, retaining walls, piers abutments, stocks, etc., are discussed.

The afternoon periods are devoted to the design and the preparation of details of such Engineering Structures as are covered in the lectures.

Prerequisites: Mathematics 15a, Geology and Mineralogy 2b, to be accompanied by Mathematics 19b.

Required in III.

Junior year, first semester, two lectures and two afternoons per week. Credit five hours.

Texts: Baker, *Masonry Construction.*
Jacoby and Davis, *Foundations.*
Hool, *Reinforced Concrete Construction.*

12b. BEAMS AND ARCHES. *Lectures and Laboratory.*

This course is a continuation of Civil Engineering 12a. The scope of the lectures is intended to cover the application of the laws of Mechanics to design of the more complicated members of Engineering structures. A theoretical study of beams under the varying conditions of loading is made, with especial consideration of the behavior of plain reinforced concrete and its application to design. The latter part of the semester work is devoted to the theory of arches. The afternoon periods are taken up with the solution of problems in design and in the preparation of the details of such engineering structures as are covered in the lectures.

Prerequisites: Civil Engineering 12a.

Required in III.

Junior year, second semester, two lectures and two afternoons per week. Credit 5 hours.

Texts: Baker, *Masonry Construction.*
Hool, *Reinforced Concrete Construction.*

13b. ROADS AND PAVEMENTS. *Lectures.* (Risher)

This course is intended to treat of the economic properties of road materials; the location, construction and maintenance of roads and streets; types of improvements, their designs and estimates of costs.

A special feature of this course is the Seminar work, which is conducted one hour each week. Throughout the year each member of the class is required to prepare and present to the class papers on some assigned subject relative to roads and road practice.

Prerequisites: Civil Engineering 1a.

Required in III.

Junior year, second semester. Three hours per week. Credit three hours.

14b. STRESSES. *Lectures and Laboratory.*

This course is outlined to include both graphical and analytical solution of stresses occurring in derricks, stacks, simple bridges and roof trusses. Stresses in beams and trusses of single and multiple systems are determined under the action or static, rolling, concentrated and prescribed wheel loads. Stresses in roofs under action of static or wind loads are also considered.

Prerequisites: Mathematics 15a, 17a and 19b.

Required in III.

Junior year, second semester, two lectures and two laboratories. Credit 5 hours.

15a. FRAMED STRUCTURES. *Lectures and Problems.* (Harris)

Treats of general methods of determining stresses in such structures as simple-span bridges, roofs, towers, three-hinged arches, etc., and of the design of individual members, such as beams, posts, and rods, to carry the determined stress.

Prerequisite: Mathematics 17b S.

Required in III.

Senior year, first semester, two hours per week. Credit two hours.

16a. ENGINEERING DESIGNING. *Laboratory.* (Harris)

The student working under the direction of the instructor works out the design of as many structures as time permits. The work includes making the necessary computations, finished drawings, and specifications.

Prerequisites: Supplementary to Civil Engineering 15a, 19a, and 21a.

Required in III.

Senior year, first semester, two afternoons per week. Credit three hours.

17b. CONTRACTS. *Lectures.* (Harris)

A lecture course in the laws of contracts, and the preparation of specifications.

Prerequisites: Completion of the Junior course.

Required in III.

Senior year, second semester, one hour per week. Credit one hour.

Text: Tucker, *Contracts in Engineering.*

19a. WATER SUPPLY. *Lectures.* (Harris)

Covers the selection, storing, transporting, purification, and delivering water to cities and towns.

Prerequisites: Civil Engineering 9b and 11b.

Required in III.

Senior year, first semester, five hours per week. Credit five hours.

Text: Turneaure and Russell, *Water Supply.*

20a. ENGINEERING LABORATORIES. (McCandliss, Risher)

In this course the student's time is divided between the cement testing laboratory and the laboratory for testing materials. Early in the semester the work consists of making complete physical tests of standard brands of natural and Portland cements, and the effects of such adulterants as free lime, sulphur acids and alkalies upon the strength and durability of the same. The

laws governing the proportionment of concretes, and mortars, are verified experimentally.

Tests are conducted to show the relationship of strength to density in mortars and concrete; the effect of fineness of grinding of a cement to its setting properties; the effect of clay upon the strength and density of concrete; the effect of commercial waterproofing ingredients upon the porosity of concrete, and such other determinations as are appropriate to a laboratory of this character. The entire course is designed to impress the student with economic truths, the adaptability and the limitations of the use of mortars and concretes for materials of engineering construction.

The latter part of the semester is devoted to the physical tests in tension compression flexura and torsion, of such materials as iron, steel, timber, stone, brick and other clay products; the study of the behavior of these materials under stress and the interpretation of the results of the investigations.

Prerequisite: Mathematics 15a.

Required in III.

Junior year, first semester, two afternoons per week. Credit three hours.

20b. ENGINEERING LABORATORIES. (McCandliss, Risher)

The character of the work done in this course is essentially the same as that of Engineering Laboratories 10a, except that only one-half as much time is devoted to the work, necessitating fewer experiments and a more limited scope.

The major portion of the time is taken up with the physical tests of iron, steel, and timber, in tension, compression, cross-bending, and torsion; the study of the behavior of these materials when subjected to stress; the interpretation of the results of the tests, and the reports upon the same.

The work in the cement testing laboratory consists of a few exercises in the physical testing of natural and Portland cements. (This course is not to be substituted for Engineering laboratory 10a.)

Prerequisites: Mathematics 15a.

Required in I.

Junior year, second semester, one afternoon per week. Credit one and one-half hours.

21a. IRRIGATION ENGINEERING AND RIVER AND HARBOR IMPROVEMENTS. *Lectures.* (Harris)

The time here allotted is given to the study of special problems arising in the design of irrigation projects, such as location of the main canal and its head works, mapping the lands, locating the secondary canals, special methods of measuring and delivering the water, necessary water consumption, etc., and to the study

of the cause and control of foods, protection of river banks, improvements of navigation, and protection and improvement of harbors.

Prerequisites: Civil Engineering 9b and 11b.

Elective.

Senior year, first semester, three hours per week. Credit three hours.

23a. RAILWAY ECONOMICS. *Lectures.* (McCandliss)

This course treats of the economic principles, of the location, revision, operation and finance of railroads.

The scope of the work covers train resistances under varying conditions of traffic, grade and curvature; locomotive performance; valuation of railway properties, estimates, etc. An important feature in this course is the assigned outside reading and reports on appropriate topics.

Prerequisite: Civil Engineering 7a.

Elective.

Senior year, first semester, three hours per week. Credit three hours.

Texts: Webb, *Economics of Railway Construction.*

25b. BRIDGES (Higher Structures). *Lectures.* (Harris)

Covers the study of effects of concentrated wheel loads on simple bridges and the study of cantilever, swing and suspension bridges and elastic arches.

Prerequisites: Civil Engineering 15a and 16a.

Required in III.

Senior year, second semester, five hours per week. Credit five hours.

Text: Johnson, *Framed Structures.*

27a. COMPRESSED AIR. *Lectures and Problems.* (Harris)

This course covers the theory of air compression, both in reciprocating machines and in centrifugal machines; also the measurement and transmission of air, and its application to the industries.

The problems include laboratory work in testing compressors and fans, determination of friction in pipes, flow through orifices, etc., and the solution of problems, such as come up in practice.

Prerequisites: Civil Engineering 9b, Mathematics 17b, and Physics 5a.

Elective.

Senior year, first semester, two lectures per week and one afternoon for laboratory and problems. Credit three and one-half hours.

Text: Harris, *Compressed Air.*

29b. SANITARY ENGINEERING. *Lectures.* (Harris)

Treats of the precautions necessary to protect water supplies from pollution and the methods available for purification of sewage. Also the construction of sewer systems for the collection and transportation of sewage and storm waters.

Prerequisite: Civil Engineering 19a.

Required in III.

Senior year, second semester, five hours per week. Credit five hours.

Text: Followell, *Sewage of Cities.*

31b. MASONRY DESIGNS AND CONCRETE STEEL. *Lectures.* (Harris)

Treats of the higher structures in masonry, such as high masonry dams, concrete steel dams, arches, and full theoretic and practical study of concrete steel construction.

Prerequisites: Civil Engineering 12a, 12b, 15a and 25b.

Required in III.

Senior year, second semester, three hours per week. Credit three hours.

32b. MASONRY DESIGNS—PRACTICE. *Laboratory.* (Harris)

The theories developed in Civil Engineering 31b are here applied in the complete design of as many structures as the time will permit. Specifications for one or more structures are required.

Prerequisite: Supplementary to Civil Engineering 31b.

Required in III.

Senior year, second semester, three hours per week. Credit 1-5 hours.

ENGLISH AND MODERN FOREIGN LANGUAGES

Associate Professor Barley, Mr. Wilkinson, Mr. DeMoss.

ENGLISH

1a. RHETORIC AND COMPOSITION. *Lectures.* (DeMoss)

Lectures on the theory of exposition and description, and the study of literature illustrative of these forms. A large amount of written work is required of the student in order that he may gain facility in the use of clear, idiomatic English. As far as possible this written work is drawn from other courses pursued by the student, thereby correlating his practice in composition with his immediate interests and activities.

Prerequisites: College entrance requirements in English.

Required in all courses.

Freshman year, first semester, five hours a week. Credit five hours.

1b. RHETORIC AND COMPOSITION. *Lectures.* (DeMoss)

This course is a continuation of 1a.

Prerequisite: 1a.

Required in all courses.

Freshman year, second semester, five hours a week. Credit five hours.

Texts: Berkeley, *College Course in Writing from Models.*
Wooley, *Mechanics of Writing.*
Canby, *English Composition in Theory and Practice.*

3a. ENGLISH PROSE. *Lectures.* (Barley)

A reading course in standard prose of the nineteenth century and of the present day. Kipling, Stevenson, Meredith, Hardy, Bennett, Galsworthy, Howells, Bret Harte, Mark Twain, and other writers will receive consideration. Attention will also be given to short stories and articles of literary merit in the various current magazines of high grade.

Prerequisites: English 1a and 1b.

Required in all courses.

Sophomore year, first semester, three hours a week. Credit three hours.

3b. *Lectures.* (Barley)

A continuation of 3a.

Prerequisites as in 3a.

Required in all courses.

Sophomore year, second semester, three hours a week. Credit three hours.

5a. EIGHTEENTH CENTURY PROSE. *Lectures.* (Barley)

Studies in DeFoe, Swift, Addison, Steele, Johnson, Goldsmith, Burke, and other prose writers of the period. A large amount of collateral reading is required.

Prerequisites: English 3a and 3b.

Required in IV.

Junior year, first semester, three hours a week. Credit three hours.

5b. SHAKESPEARE AND HIS CONTEMPORARIES. *Lectures.* (Barley)

A reading course in Elizabethan drama, preceded by a consideration of the development of English drama from its origin through the miracle, morality and interlude into regular drama. Altogether about twenty plays are read, and some of the problems incident to the period are investigated.

Prerequisites: 3a and 3b.

Required in IV.

Junior year, second semester, three hours a week. Credit three hours.

19a. ENGINEERING WRITING. *Lectures.* (Barley)

An advanced course in oral and written technical reports, and in the details and problems of engineering writing.

Senior year, first semester, two hours a week. Elective in all courses. Credit two hours.

MODERN FOREIGN LANGUAGES.

Candidates for degrees in Curricula I., II., and III. are required to complete two semesters' work in either French, German, or Spanish. Candidates for degrees in Curriculum IV. are required to complete four semesters' work in each of any two of the modern foreign languages offered, namely, French, German, and Spanish. Students who offer foreign languages for credit must satisfy the department by examination or otherwise that the work so offered is the equivalent in scope and intensity of the courses given by the department.

7a. ELEMENTARY GERMAN. *Lectures.* (Wilkinson)

Prerequisites: English 1a and 1b.

Sophomore year, first semester, three hours a week. Credit three hours.

Texts: Thomas, *Practical German Grammar.*
Holzwarth, *Gruss aus Deutschland.*

(Not offered in 1915-1916.)

7b. ELEMENTARY GERMAN. *Lectures.* (Wilkinson)

Prerequisite: 7a.

Sophomore year, second semester, three hours a week. Credit three hours.

Texts: Same as in 7a.
Wildenbruch, *Das Edle Blut.*
Wells, *Drei Kleine Lustspiele.*

(Not offered in 1915-1916.)

9a. SCIENTIFIC GERMAN. *Lectures.* (Wilkinson)

Prerequisites: 7a and 7b or equivalent; English 1a and 1b.

Junior year, first semester, three hours a week. Credit three hours.

Texts: Thomas, *Practical German Grammar.*
Wallentin, *Grundzuge der Naturlehre.*
German Scientific Periodicals.

9b. SCIENTIFIC GERMAN. *Lectures.* (Wilkinson)

Junior year, second semester, three hours a week. Credit three hours.

Texts: Same as in 9a.

11a. ELEMENTARY FRENCH. *Lectures.* (Wilkinson)

Prerequisites: English 1a and 1b.

Sophomore year, first semester, three hours a week. Credit three hours.

Texts: Fraser and Squair, *French Grammar.*
Merimee, *Carmen.*
Lazare, *Elementary French Composition.*

11b. ELEMENTARY FRENCH. *Lectures.* (Wilkinson)

Prerequisite: 11a.

Sophomore year, second semester, three hours a week. Credit three hours.

Texts: Same as in 11a.
Dumas, *Les Trois Mousquetaires.*
Augier et Sandeau, *Le Gendre de M. Poirier.*
Labiche et Martin, *Le Voyage de M. Perrichon.*

13a. SCIENTIFIC AND ADVANCED FRENCH. *Lectures.* (Wilkinson)

Prerequisites: 11a and 11b or equivalent; English 1a and 1b. Junior year, first semester, three hours a week. Credit three hours.

Texts: Fraser and Squair, *French Grammar.*
Daniels, *Scientific French Readings.*
(Not offered in 1915-1916.)

13b. ADVANCED FRENCH. *Lectures.* (Wilkinson)

Prerequisites: 11a and 11b or equivalent; English 1a and 1b. Junior year, second semester, three hours a week. Credit three hours.

Texts: Fasnacht, *Advanced French Composition.*
Selections from the French drama and novel of the eighteenth and nineteenth centuries.
(Not offered in 1915-1916.)

15a. ELEMENTARY SPANISH. *Lectures.* (Wilkinson)

Prerequisites: English 1a and 1b.
Sophomore year, first semester, three hours a week. Credit three hours.

Texts: Hills and Ford, *A Spanish Grammar.*
Isla, *La Historia de Gil Blas de Santillana.*

15b. ELEMENTARY SPANISH. (Wilkinson)

Prerequisite: 15a.
Sophomore year, second semester, three hours a week. Credit three hours.

Texts: Same as 15a.

17a. ADVANCED SPANISH. *Lectures.* (Wilkinson)

Prerequisites: 15a and 15b.
Senior year, first semester, three hours a week. Credit three hours.

Texts: Hills and Ford, *A Spanish Grammar.*
Umphrey, *Spanish Prose Composition.*
Valdes, *La Hermana San Sulpicio.*
Valera, *El Comendador Mendoza.*
Galdos, *Dona Perfecta.*

17b. ADVANCED SPANISH. *Lectures.* (Wilkinson)

Prerequisite: 17a.
Senior year, second semester, three hours a week. Credit three hours.

Texts: First two under 17a.
Hartzenbusch, *La Coja y el Encogido.*
Ayala, *Consuelo.*
Tamayo, *Lo Positivo.*
Nunez de Arce, *El Haz de Lena.*
Ibanez, *Sangre y Arena.*

GEOLOGY AND MINERALOGY

Professor Cox, Assistant Professor Dake, Mr. Radcliffe, Mr. Bridge, Mr. Shotwell, Mr. Wilson.

Equipment.

The geological and mineralogical laboratories are on the second floor of Norwood Hall. They are supplied with suitable tables for the examination of rocks and minerals. The equipment of the department includes reference, working, and cabinet collections of minerals, ores, rocks, and fossils and many specimens illustrating metallurgical processes; a working collection of wooden and glass crystal models and natural crystals; full sets of maps and reports and a set of geological relief models.

There is also a collection of thirty-five hundred specimens, representing the mineral wealth of Missouri, consisting of coal, clays of many sorts, building stones, and ores of lead, zinc, iron, and copper. The minerals occurring as gangue with the metalliferous deposits of the State are also well represented. There is also a complete collection of the economic minerals of Missouri and a good economic geological collection representing the world at large. This collection was a part of the Missouri Mineral Exhibit displayed at the World's Fair at Chicago and was presented to the School of Mines and Metallurgy by the General Assembly in 1895.

In addition to the above-mentioned collection the State Board of Equalization assigned to the School the specimens, models, maps, and machinery which constituted the Missouri Mining Exhibit at the St. Louis Exposition, thus giving to the School a large amount of valuable equipment.

The Museums contain crystals and minerals from various parts of the world, the important mining districts of the State of Missouri being especially well represented by the economic collection from Southwestern Missouri, the great geological relief map, polished stone tables and ornamental stones, and other complete collections of the Missouri Building of the St. Louis Exposition.

Rock breaking and section machines, instruments for geological surveys, petrographic microscopes, thin mineral and rock sections, and lantern slides are included in the equipment of this department.

MINERALOGY.

Courses.

1a. MINERALOGY. *Lectures and Laboratory.*
(Radcliffe, Bridge, Shotwell)

Elementary crystallography, including the study of models and natural crystals, with oral and written recitations, eleven weeks; practice in blowpipe analysis with determinaton of unknowns, four weeks; introduction to descriptive and determinative mineralogy the remainder of the semester.

Prerequisites: Chemistry 1b 3b, 4b.

Required in I. and II.

Sophomore year, first semester, two hours' lectures and six hours' laboratory per week. Credit five hours.

Texts: Patton, *Lecture Notes on Crystallography.*
Butler, *Handbook of Blowpipe Analysis.*
Dana, *Textbook of Mineralogy.*

1b. MINERALOGY. *Lectures and Laboratory.*
(Radcliffe, Bridge, Shotwell, Wilson)

Descriptive and determinative mineralogy. A study of the fundamental principles of classification and the distinctive characteristics of minerals with a thorough drill in the recognition of about two hundred species.

Prerequisite: Mineralogy 1a.

Required in I. and II.

Sophomore year, second semester, two hours' lectures and six hours' laboratory per week. Credit five hours.

Text: Dana, *Textbook of Mineralogy.*

2b. C. E. MINERALOGY. *Lectures and Laboratory.* (Bridge)

A study of the common ore and rock forming minerals and types of rocks. The necessary lectures are given during the regular laboratory periods. This course is intended for the Civil Engineering students, the same ground being covered more thoroughly by Courses 1a, 1b, and 5a, so that full credit may not be given for it and one or more of these courses, and it may not be substituted for any part of them.

Prerequisite: Chemistry 1b.

Required in III.

Sophomore year, second semester, three hours per week. Credit two hours.

11a. OPTICAL MINERALOGY. See Geology 11a.

GEOLOGY.

Courses.

3a. GENERAL GEOLOGY. *Lectures.* (Dake)

Dynamic geology. A somewhat detailed account of geologic processes. The larger topics are treated more exhaustively than in the required text. Local field trips.

Prerequisites: Either 2b or 1a and 1b, and accompanied in 5a.

Required in I., II., and III.

Junior year, first semester, four hours per week. Credit four hours.

Text: Scott, *An Introduction to Geology.*

3b. GENERAL GEOLOGY. *Lectures.* (Dake)

Introductory structural and historical geology. Typical geologic structures and their effects upon the physiographic development of the earth's surface are considered for the first six weeks. Geologic history is then traced from the beginning of the record to the present, as much attention as possible being paid to the rock-systems and their contained fossils, with some reference to geographic changes and organic evolution.

Prerequisites: Geology 3a. To be accompanied by Geology 4b or 6b.

Required in I. and II.

Junior year, second semester, four hours per week. Credit four hours.

Text: Scott, *An Introduction to Geology.*

4b. GENERAL GEOLOGY. *Laboratory.* (Dake, Bridge)

Laboratory exercises in reading topographic and geologic maps; in the construction of profile and geologic sections and simple geologic maps, and in the recognition of twenty index fossils. These exercises are designed to illustrate the subject-matter of the earlier lectures of Course 3b, and occupy nine weeks; excursions and field practice in elementary geologic mapping the remainder of the semester.

Prerequisite: Geology 3a. To accompany Geology 3b.

Required in I. and II.

Junior year, second semester, six hours per week. Credit three hours.

References: Hayes *Handbook for Field Geologists.*
Geikie, *Outlines of Field Geology.*
Prof. Paper *U. S. Geol. Survey No.* 60.

5a. LITHOLOGY. *Lectures and Laboratory.* (Radcliffe, Bridge, Shotwell)

A study of the structure, texture, mineral and chemical composition, and the manner of formation and occurrences of igneous, sedimentary, and metamorphic rocks. This course is adequate for all general field determinations.

Prerequisites: Mineralogy 1a and 1b, to be accompanied by Geology 3a.

Required in I. and II.

Junior year, first semester, one hour lecture and three hours' laboratory per week. Credit two and one-half hours.

Text: Kemp, *Handbook of Rocks.*

6b. C. E. GEOLOGY. *Laboratory.* (Dake, Bridge)

Laboratory exercises in reading topographical and geologic maps, and in the construction of profile and geologic sections and simple geologic maps.

Prerequisites: Geology 3a.

Required in III.

Junior year, second semester, six hours per week for the first half of the semester. Credit one and one-half hours.

7a. GEOLOGY OF THE UNITED STATES. *Lectures.* (Dake)

The physiography, stratigraphy, economic products, and geologic structure and history of the chief geologic divisions of the United States are summarized in the lectures.

Prerequisites: Geology 3b, either 4b or 6b, and either 2b or 5a.

Senior year, first semester, three hours per week. Credit three hours.

Text: Blackwelder, *Handbook of Regional Geology: the United States.*

9a. ECONOMIC GEOLOGY. *Lectures.* (Cox)

A study of the origin, occurrence, and distribution of the metallic ores. Various type deposits of the world are considered, special attention being given to those of the United States. Written reports are required for each district studied; reference always being made to the original reports, thus familiarizing the student with the various technical publications and their usage. The ores of the following metals are considered: zinc, lead, copper, gold, silver, nickel, cobalt, iron, manganese, tin, mercury, tungsten, platinum, and aluminum. Trips to local points of interest.

Candidates for the degree of Bachelor of Science in Mine Engineering or Metallurgy taking this course must also take the geology part of the Course 12, Senior Trip.

Prerequisites: Geology 3b, either 4b or 6b, and either 2b or 5a.

Senior year, first semester, five hours per week. Credit five hours.

Text: No text required. Reference largely to reports by the United States and State geological surveys.

9b. ECONOMIC GEOLOGY. *Lectures.* (Cox)

A study of the origin, occurrence, and distribution of the economic deposits of the non-metals. Reference is made to those technical reports which describe the most important deposits, and a written summary is required for each district studied. The subjects covered are as follows: coal, oil and gas, clays, cements, gypsum, salt, sulphur, sulphides, building stone, abrasives, gems, soils, and fertilizers. Trips to local points of interest.

Students taking this course who have not taken Course 9a will be given special work while the remainder of the class is taking the Senior Trip.

Prerequisites: Geology 3b, either 4b or 6b, and either 2b or 5a.

Senior year, second semester, three hours per week. Credit three hours.

Text: No text required. Reference largely to reports of the United States and State geological surveys.

11a. PETROGRAPHY. *Lectures and Laboratory.* (Cox, Dake)

The semester is devoted to the study of optics as applied to the determination of minerals by the polarizing microscope, the identification of minerals in thin sections, and the grinding of rock and mineral thin sections.

Prerequisites: Geology 3b, 4b, and 5a, and Physics 3a and 4a.

Senior year, first semester, three hours' lecture and nine hours' laboratory per week. Credit seven and one-half hours.

Text: Luquer, *Minerals in Rock Sections.*

11b. PETROGRAPHY. *Lectures and Laboratory.* (Cox)

A study of nomenclature, relations, and alterations of rocks, together with the petrographic analysis and the recalculation of the chemical analysis of rocks.

Prerequisite: Geology 11a.

Senior year, second semester, three hours' lecture and six hours' laboratory per week. Credit six hours.

Texts: Kemp, *Handbook of Rocks*, with one of the following:
Iddings, *Rock Minerals.*
Winchell, *Elements of Optical Mineralogy.*
Johannson, *Determination of Rock-Forming Minerals.*

12. SENIOR TRIP.

During the second semester of the Senior year, a three weeks' trip is taken to Joplin, St. Louis, Flat River, and other points in the Southeastern Missouri Lead District, for the purpose of studying Mining, Ore Dressing, Smelting, Geology, and Power Plants of these districts. The geology portion of these trips is required of all candidates for the degrees in Mining, Engineering and Metallurgy who have taken Course 9a.

Prerequisite: Geology 9a.

Senior year, second semester.

13b. STRUCTURAL GEOLOGY. *Lectures.* (Cox)

An advanced course in the study of rock deformation, including a review of the theories of the origin of the earth; a discussion of the zones of rock fracture and rock flowage; a classification and discussion of cleavage, joints, faults, folds, autoclastic rocks, conglomerates, and pseudo-conglomerates; and a consideration of mountain building forces, together with the horizontal and vertical depth affected, with application to special districts.

Prerequisites: Geology 3b, either 4b or 6b, and either 2a or 5a.

Senior year, second semester, three hours per week. Credit three hours.

14a. FIELD GEOLOGY. *Field Work.* (Cox)

The course consists of both field and laboratory work, the two being varied to suit the weather. The field work consists of the making of topographic and geologic maps, with suitable sections and reports, of assigned areas. The laboratory work includes the making of sections and maps and the final drafting of the field work.

Prerequisites: Geology 3b, either 4b or 6b, either 2b or 5a, and Civil Engineering 4.

Senior year, first semester, six hours per week. Credit three hours.

15b. GEOLOGY CONFERENCE. (Cox)

The conference consists of a discussion by the students and instructors of geologic problems and literature, each student being assigned certain work upon which he must report to the class.

Prerequisite: Geology 9a.

Senior year, second semester one hour per week. Credit one hour.

16b. ADVANCED GEOLOGY. *Laboratory.* (Dake)

An advanced course in the study and interpretation of the topographic and geologic maps.

Prerequisites: Geology 3b and either 4b or 6b.

Senior year, second semester, six hours' lectures and sixty hours' laboratory work for the semester. Credit two hours.

17a. OIL AND GAS. *Lectures.* (Cox)

A detailed study of the origin and occurrence of the various oil and gas deposits.

Prerequisites: Mineralogy 1b or 2a and Geology 3b.

Senior year, first semester, two hours a week. Credit two hours.

17b. OIL AND GAS. *Lectures.* (Cox)

Oil drilling, testing and refining.

Prerequisite: Geology 17a.

Senior year, second semester, two hours a week. Credit two hours.

18b. OIL AND GAS. *Laboratory.* (Cox)

Laboratory work in the study of field maps and the testing of oils.

Prerequisites: Must be accompanied by Geology 17b and either 4b or 6b.

Senior year, second semester, three hours a week. Credit 1.5 hours.

38. JUNIOR TRIP.

At the end of the school year the members of the Junior class make a three weeks' trip to Colorado and Utah, or other mining districts. The purpose of the trip is to give an opportunity for the study of the geology, mining, and concentration of ores in the districts visited.

Credit may also be obtained for this trip in the following manner:

The student may obtain employment at any mine, mill, or smelter of his own selection, for a period of not less than six weeks. This work will be accepted as a substitute for the regular trip only when accompanied by a suitable report on the mining, metallurgy, and geology of the district in which he is employed. Outlines of these reports will be furnished by the various departments. Affidavits will be furnished the students to be signed by the mine or mill officials, by whom he was employed, stating the time of such employment and nature of work.

Credit will be given for this course only to candidates for degrees of B. S. in Mining and Metallurgy.

Prerequisites: Mining 5b, Geology 3b and 4b, and Metallurgy 31b.

Junior year, Summer session. Credit (geology portion) 2 hours toward Senior electives in I. and II.

MATHEMATICS

PROFESSOR DEAN, ASSOCIATE PROFESSOR GARRETT, MR. THORNBERRY.

While the utility of mathematical study as a mental discipline is duly recognized, the ultimate intention of the student is kept in mind, and the matter and methods of the courses are adjusted, as nearly as possible, to meet the demands of subsequent studies and professional practice.

Courses.

1a. COLLEGE ALGEBRA. *Lectures.* (Thornberry)

Theory of limits, logarithms, progressions, binominal theorem, undetermined coefficients, series and solution of higher equations. Special attention is paid to graphical solutions and practical applications.

Prerequisites: Entrance requirements.

Required in I., II., III. and IV.

Freshman year, five-hours per week, first twelve weeks. Credit three hours.

Text: Hall and Knight, *College Algebra.*

3a. PLANE TRIGONOMETRY. *Lectures.* (Thornberry)

Solution of plane triangles, reduction and transformation of trigonometric expressions, solution of trigonometric equations.

Prerequisite: Mathematics 1a.

Required in I., II., III. and IV.

Freshman year, remainder of first semester after 1a. Credit two hours.

Text: Taylor and Puryear, *Trigonometry.*

5b. SPHERICAL TRIGONOMETRY. *Lectures.* (Thornberry)

Continuation of Mathematics 3a, taking up more difficult parts of analytical trigonometry, solution of spherical triangles, and simpler problems of spherical astronomy.

Prerequisite: Mathematics 3a.

Required in I., II., III. and IV.

Freshman year, second semester, first five weeks, five hours per week. Credit two hours.

Text: Taylor and Puryear, *Trigonometry.*

7b. ANALYTICAL GEOMETRY. *Lectures.* (Thornberry)

The object of this course is to familiarize the student with methods rather than with any particular set of curves. Special attention, however, is given to those forms of the equations of the conic sections which occur in technical literature.

Prerequisite: Mathematics 5b.

Required in I., II., III., and IV.

Freshman year, remainder of second semester after Mathematics 5b, five hours per week. Credit three hours.

Text: Ashton, *Analytical Geometry.*

9a. DIFFERENTIAL CALCULUS. *Lectures.* (Dean)

The student is thoroughly drilled in the derivation of formula, and the application of derivatives in the solution of problems in maxima and minima, in curve tracing, velocity, and acceleration, expansion of functions.

Prerequisite: Mathematics 7b.

Required in I., II., and III.

Sophomore year, first twelve weeks of first semester, four hours per week. Credit three hours.

Text: Granville, *Calculus.*

11a, 11b. INTEGRAL CALCULUS. *Lectures.* (Dean)

The student is drilled in the integration of forms occurring in mechanics and physics, in evaluating areas, moments, moments of inertia, in finding centers of gravity, center of stress, and in the derivation and application of fundamental formulae of hydrostatics and hydraulics.

Prerequisite: Mathematics 9a.

Required in I., II., and III.

Sophomore year, five hours per week, after 9a, and first six weeks of second semester. Credit two hours on each semester.

Text: Granville, *Calculus.*

13b. DIFFERENTIAL EQUATIONS. (Dean)

Integrable forms of the differential equations of mechanics and physics, applications of partial differentiation and partial integration, theory of attraction, dynamics of a particle, and thermodynamics of perfect gases.

Prerequisites: Mathematics 11a and 11b.

Required in I., II., and III.

Sophomore year, second semester, five hours per week. Credit three hours.

Texts: Cohen, *Differential Equations.*
Dean, *Manuscript Notes.*

15a. STATICS. *Lectures.* (Garrett)

It is the aim in this course to train the student to apply the principles of statics to practical rather than theoretical problems.

Prerequisites: Mathematics 11a and 11b.

Required in I., II., and III.

Junior year, four hours' lectures per week, first half of either semester; credit two hours.

Text: Maurer, *Technical Mechanics.*

Notes by instructor.

17a. MECHANICS OF MATERIALS. *Lectures.* (Garrett)

The more elementary and fundamental parts of the subject are here taken up. The student is given a thorough drill in the application of principles to simple problems of design and in the use of standard handbooks.

Prerequisite: Mathematics 15a.

Required in I., II., and III.

Junior year, second half either semester, four hours per week. Credit two hours.

Text: Merriman, *Mechanics of Materials.*

19b. MECHANICS OF MATERIALS. *Lectures.* (Garrett)

This course begins with the study of the elastic curve and includes the more advanced topics. As in the preceding course a thorough drill in the practical application of the principles developed forms an important part of the work.

Prerequisite: Mathematics 17a.

Required in I., II., and III.

Junior year, first half either semester, four hours per week. Credit two hours.

Text: Merriman, *Mechanics of Materials.*

21b. DYNAMICS. *Lectures.* (Garrett)

This course includes kinematics and kinetics with technical applications.

Prerequisite: Mathematics 15a.

Required in I., II., and III.

Junior year, second half of either semester, four hours per week. Credit two hours.

Text: Maurer, *Technical Mechanics.*

Elective Courses.

Juniors, Seniors, and Graduates who have ability and preparation may elect courses in advanced pure mathematics, analytical and applied mechanics, mathematical theory of electricity and magnetism and other branches of mathematical physics. These courses are not scheduled and special arrangements will be made to suit the convenience of the instructor and student.

METALLURGY AND ORE DRESSING

Professor Copeland, Associate Professor Mann, Mr. Clayton, Mr. McNely.

Equipment.

The assay laboratory has a floor space of forty-eight hundred square feet. In the main room are twenty coal-fired, double-muffle assay furnaces, twelve gasoline-fired muffle furnaces, and ten coke-fired furnaces. Desks containing lockers, pulp balances, and fluxes are arranged close to the furnaces.

A room 16 by 16 feet separated from the furnace laboratory by glass partitions, is used for parting. There are in this room the necessary hot plates, acid jars, and annealing muffles. The desks in this laboratory are topped with white tiling.

The balance room is 20 by 20 feet and is lighted only from the north. It is easily kept at constant temperature. There are twenty-four balances suitable for weighing gold. A number of these balances have the multiple-rider attachment.

For chemical work in connection with metallurgy there is a well-lighted room having fifty-six lockers and fifty-six desks. Each desk is provided with gas, compressed air, and water. There is in the room ample hood space; in fact, the laboratory has everything necessary for general chemical work.

There is, in main furnace room, a circular water-jacket blast furnaces, 20 inches in diameter at the tuyeres and 7-foot smelting column. This furnace is used for lead and copper smelting. For roasting ores a hand reverberatory furnace, with a hearth 4½ by 9 feet, is provided. This laboratory contains also an experimental pot roaster, an experimental zinc distilling furnace, three La Chatlier thermo-electric pyrometers, and a Wanner optical pyrometer.

A stock room, containing chemicals, clay goods, glassware, and other supplies, serves all the laboratories. The ore-sample room is especially well equipped. It contains more than 1 000 samples of ore of varied classes. Each sample is stored away in paper sacks, all ready for issuing to the students. Each sample has been prepared and carefully assayed. Enough of each lot of ore has been prepared to give 200 to 300 samples of the same lot. The sample room, therefore, contains more than 1 000 different samples of ore, each sample being divided into 200 or more smaller samples, each of the smaller samples being ready for immediate issue.

METALLURGY AND ORE DRESSING

MINE TUNNEL

Throughout the metallurgical and ore-dressing laboratories care has been taken that each furnace, each piece of apparatus, should be so arranged as to be fitted best for that testing work which must be so great a part of the student's work. In all the laboratory work, in addition to demonstrating the theories and principles explained in the classroom, the attempt is made to give the man ability to do a day's work and to teach him to use both his head and his hands.

The main floor of the new ore-dressing laboratory occupies a space of forty-eight hundred square feet and a mezzanine floor provides an additional space of thirteen hundred square feet. The equipment of the laboratory is as follows: The crushing and sampling department contains a gyratory breaker, a Dodge breaker, a pair of 9-in. by 12-in. rolls, two plane shaking screens, two Vezin samplers, two bucket elevators, three belt conveyors and six ore storage bins, each equipped with an automatic feeder. For fine crushing and amalgamation tests are provided a three-stamp mill, with amalgamated plates, and a 3½ foot Huntington mill.

Ores are prepared for concentration by the following series of machines: Three trommel screens, a duplex Callow traveling belt screen, a Richards pulsator classifier, a four-spigot Richards vortex classifier, a three-spigot cone classifier, a small Tamarack classifier, and four Callow settling cones.

Methods of concentrating coarsely crushed ores are illustrated by three five-cell differential motion Harz jigs a Richards pulsator jig, and a small model of the Hancock jig. Sands are treated on two laboratory-size Wilfley tables, one laboratory Card table, and one laboratory James table. A four-foot Frue vanner and a five-foot Sperry slimer are provided for the treatment of fine materials.

Two direct-connected motor-driven centrifugal sand pumps are used for elevating finely crushed ore to the screening and classification system.

The sample finishing room contains a small Blake crusher, a small gyratory breaker, a disc grinder, a coffee mill, a pair of rolls, a number of bucking boards and mullers, a laboratory tube mill, and an electric sample dryer.

The cyanide unit contains a laboratory leaching plant with all necessary tanks, a 16-in. Hendryx clay agitator, a 14-in. Hendryx combination agitator and filter, and a six-leaf 12-in by 12-in filter press.

Ores suited to a magnetic concentration are treated on a Knowles magnetic separator, and for the preparation of such ores a cylindrical dryer and roaster, together with a plane impact screen for dry sizing, is provided.

Throughout the mill, wherever possible, the practice of driving each machine with an individual motor has been followed.

It is recognized that the school cannot give students, in the brief time at its disposal, that skill which comes from long practice, but it is the aim to give such training in the fundamental principles and their application that students may become useful immediately on their entrance into the actual practice of their chosen profession. All metallurgical courses are accompanied by graded metallurgical problems.

An important feature of the instruction is experimental investigation in the metallurgical treatment of various ores.

Courses.

1a. FIRE ASSAYING. *Lectures.* (Mann)

This course deals with the theory of fire assaying as practiced in the laboratory. The points discussed are outlined under Metallurgy 2b.

Prerequisites: Chemistry 1a and 2a.

Required in I. and II.

Junior year, first semester, two hours per week. Credit two hours.

Texts: Lodge, *Notes on Assaying.*
Fulton, *Assaying.*

2b. FIRE ASSAYING. *Laboratory.*
(Copeland, Mann, Clayton, McNely)

This work includes the assay, by scorification and crucible methods of ores from the various districts of the United States. Copper ores, copper mattes, and copper bullions are assayed by fire and by the combination method. Lead ores and furnace products are assayed for lead and for gold and silver. Assays of cyanide solutions, of zinc-box residues, of silver bullion, of gold bullion, of lead bullion and of silver-mill precipitate, are included in this course. During the course the student has practice with coal furnaces, coke furnaces, and gasoline furnaces. Besides doing the ordinary work of assaying, the student studies the losses occurring. He learns the effects of different schemes of firing the furnaces by making analysis of the flue gases and by pyrometric measurements. The laboratory is so arranged that even with large classes a student is not hampered by other students and he learns to handle a large amount of work with the best utilization of his time.

Prerequisites: Chemistry 1a and 2a. To be preceded by Geology and Mineralogy 1a.

Required in I. and II.

Junior year, second semester, nine hours per week. Credit four and one-half hours.

Texts: Lodge, *Notes on Assaying.*
Fulton, *Assaying.*

3b. METALLURGY AND THE METALLURGY OF IRON AND STEEL. *Lectures.* (Clayton)

This course covers the same as outlined under Metallurgy No. 39a and 39b but with less detail. It is intended primarily for the men studying Mining and Civil Engineering.

Prerequisites: Chemistry, Geology and Mineralogy.

Required in I., and III.

Junior year, second semester, three hours a week. Credit three hours.

Texts: Stoughton, *Metallurgy of Iron and Steel.*
Fulton, *Principles of Metallurgy.*
Hofman, *General Metallurgy.*
Richards, *Metallurgical Calculations. Vols. I. and III.*

5a. METALLURGY OF THE NON-FERROUS METALS. *Lectures.* (Copeland, Mann)

This course includes a study of the metallurgy of lead, copper, zinc, gold, silver, tin, antimony, and aluminum. The greater part of the time is spent on the metallurgy of lead, copper, zinc, gold, and silver.

Metallurgy of Lead. The course in the metallurgy of lead includes work along the following general lines: The properties and uses of lead, its alloys, and compounds. The ores of lead and methods and principles of their sale. Principles and practice of sampling ores and products. The general principles made use of in the winning of lead from its ores. The treatment of lead ores in the reverberatory smelting furnace. The winning of lead from its ores by smelting in the ore hearth or Scotch hearth, considerable attention being paid to this method on account of its importance with the ores of the Mississippi Valley. The roasting of lead ores and the strides that have recently been made in this important preliminary in the lead blast-furnace. The winning of ores in the lead blast-furnace. This heading is, of course, an important one in the subject and under it are taken up the blast-furnace plant, the chemistry of the blast-furnace, the calculation of furnace charges, the calculation of costs of smelting, the handling of products, particularly the smoke or fume. The desilverization of base bullion by means of the Parkes, Pattinson, and cupellation processes, as well as by the Betts process. Throughout this course, as well as the other courses in this department, the work is accompanied by problems which bring out the ideas that the class-room work considers.

Texts: Hofman, *Metallurgy of Lead.*
Collins, *Metallurgy of Lead.*
The Articles Appearing in the Technical Journals.

METALLURGY OF COPPER. The metallurgy of copper is considered along the following general lines. The properties and uses of copper, its compounds, and its alloys. The markets for copper and its ores and the principles underlying their sale and price. The ores of copper. The smelting of roasted and oxidized ores of copper to black copper is touched only briefly. The roasting of copper ores as a preliminary to blast-furnace and reverberatory smelting. The handling of the smoke from copper furnaces to save the values contained therein and to remove from these gases their injurious constituents. The smelting of roasted ores to matte in the reverberatory furnace. The smelting of roasted ore to matte in the blast-furnace either with or without the attempt to volatilize a considerable portion of the sulphur. The smelting of raw massive sulphides to matte in the blast-furnace, or pyrite smelting. The converting of copper matte to blister copper in the basic and in the acid converter. The furnace refining of copper. The production of copper from matte by the various roast-reaction or roast-smelting methods. The electrolytic refining of copper.

Texts: Peters, *Practice of Copper Smelting.*
Peters, *Principles of Copper Smelting.*
Hofman, *Metallurgy of Copper.*
References in the Technical Journals.

METALLURGY OF ZINC. The metallurgy of zinc is considered under the following headings: The properties and uses of zinc, its alloys, and its compounds. The ores of zinc and the methods and principles underlying their sale. The roasting of zinc ores with a brief study of the use of zinc ores as a source of sulphuric acid. The distillation of zinc ores and the furnaces suited for this purpose. The factors on which the success of the distillation depends. The manufacture of retorts and condensers. The laws of condensation of vapor to liquid and their application to the condensation of zinc vapors. The products of zinc smelting, and the methods of handling and treating these products. The cost of smelting zinc ores figured on the basis of a number of typical ores. The refining of spelter. The markets for spelter and the various brands of spelter. Special schemes other than the ordinary methods that have been used or proposed for use in the winning of zinc from its ores. The manufacture of zinc oxide pigment. Throughout the course problems are given to illustrate the ideas set forth in the class.

Text: Ingalls, *Zinc.*

METALLURGY OF GOLD AND SILVER. The metallurgy of gold. The work in this course includes lectures and recitations along the following general lines: The properties of gold, gold

alloys, and the compounds of golds. The winning of gold from placer ground by dredging and hydraulicing, including methods of investigating the value of placers. The chlorination and bromination of gold ores are considered more in the light of the historic value of these processes than for their present importance as schemes of gold extraction. The amalgamation methods for silver and gold ores are taken up in detail in the course in ore dressing.

The metallurgy of silver is considered as suggested by the following headings: The properties of silver, of its alloys, and of the compounds of silver. The winning of silver from its ores by the various leaching schemes that were formerly of greater importance than at present. These schemes include the Augustin process, the Ziervogel or Argo process, the various methods of hyposulphite leaching; they are considered only briefly. The greater part of the time of the course in gold and silver is devoted to the study of the cyanide process which is considered in considerable detail. The parting of gold and silver by the various acid and electrolytic schemes. The winning of gold and silver from their ores by the various smelting schemes is considered under the head of the metallurgy of lead and copper.

Texts: Rose, *Metallurgy of Gold.*
Collins, *Metallurgy of Silver.*
Julian and Smart, *Cyaniding.*
Clennell, *Cyaniding.*
The Technical Journals.

Prerequisites: Metallurgy 3b and Chemistry 6b.

Senior year, first semester, five hours per week. Credit five hours.

5b. METALLURGY OF THE NON-FERROUS METALS. *Lectures.* (Copeland, Mann)

This is a continuation of Metallurgy 5a.

Prerequisites: Metallurgy 3b and Chemistry 6b.

Senior year, second semester, three hours per week. Credit three hours.

6a. METALLURGY. *Laboratory.* (Mann, Clayton)

This course covers the testing of ores for process treatment. Ores are tested by cyaniding, chlorination, amalgamation, lixiviation. concentration, and by combination methods. With aid of smelter schedules, the smelting costs are calculated and the net dollars and cents returns are balanced against the best results by any method or combination of methods, worked out in the laboratory. The endeavor is made, not only to teach metallurgical principles in the laboratory, but also to bring home to the student the great effect that freight rates and such other factors have on

the treatment which an ore should receive. Experiments are made in the reverberatory and the "pot" roasting of ores, and on blast-furnace smelting of ores. Furnace heat equations are made by each student from data collected by himself.

Prerequisites: Metallurgy 1b, 2b, and 3b.

Senior year, first semester, four hours per week. Credit 1.5 hours.

Text: Howe, *Metallurgy Laboratory Experiments.*

8a. METALLURGY. *Laboratory.* (Copeland, Mann, Clayton)

A more extended course than 6a. Planned for students specializing in metallurgy.

Prerequisites: As in 6a.

Senior year, first semester, seven hours per week. Credit three hours.

Recommended for II.

Text: As in 6a.

9a. ELECTRO-METALLURGY. *Lectures.* (Clayton)

Lectures are given covering the electro-metallurgical processes that are in use. Efficiency and engineering calculations based on these processes are given.

Prerequisites: Metallurgy 3b, Physics 1b and 3a, Chemistry 9a, 10a, and 7a.

Senior year, first semester, five hours per week. Credit five hours.

10a. ELECTRO-METALLURGY. *Laboratory.* (Clayton)

This course gives a study of the principles of electro-metallurgy from the standpoint of experiments actually performed. Tests are made on the electrolytic refining of copper and of lead bullion. Experiments are performed and calculations as to efficiency are made on electric smelting.

Prerequisites: Physics 1b and 3a, Chemistry 9a, 10a, and 7a. Accompanied by Metallurgy 9b.

Senior year, first semester, six hours per week. Credit three hours.

12. SENIOR TRIP.

During the second semester of the Senior year, a three weeks' trip is taken to Joplin, St. Louis, Flat River, and other points in the Southeast Missouri Lead District, for the purpose of studying the Mining, Ore Dressing, Smelting, Geology, and Power Plants of these districts. The metallurgy part of this trip is required of all candidates for degrees in Mining Engineering and Metallurgy who take Courses 5b Metallurgy and 33b Metallurgy.

Prerequisites: Metallurgy 5b, 33b.

Senior year, second semester.

13a. METALLURGY PROBLEMS. (Clayton

These problems aim to cover the common ones that the metallurgist meets in practice.

Prerequisite: Metallurgy 3b. To accompany Metallurgy 5a.

Senior year, first semester, two hours per week. Credit two hours.

Texts: Richards, *Metallurgical Calculations.*

15b. METALLURGICAL MEMOIRS. *Lectures.* (Clayton)

The student in the Metallurgy Curriculum is required to do a considerable amount of technical reading in German and English. Carefully prepared abstracts of valuable current articles are presented and read by each student.

Prerequisite: Metallurgy 5a.

Senior year, second semester, one hour per week. Credit one hour.

17a. METALLURGY CONFERENCE. *Lectures.* (Mann)

The lectures cover the work being given at the time in the laboratory in Metallurgy 6a.

Prerequisite: Metallurgy 3b. To accompany Metallurgy 6a.

Senior year, first semester, one hour per week. Credit one hour.

19a. METALLURGY PLANT. *Lectures.* (Copeland)

The arrangement of various metallurgical works are studied. The advantages and disadvantages of different equipments are given.

Prerequisites: Metallurgy 3b, 5a, and 5b.

Graduate course, first semester, two hours per week. Credit two hours.

20a. METALLURGY PLANT DESIGN. *Laboratory.*
(Copeland)

This is a drafting-room course, and the student is given problems to solve in detail, covering a part of the class-room discussions. Each student is required to submit complete drawings, specifications, and estimations of cost.

Prerequisites: Shop Practice and Drawing 2b, Metallurgy 3b, 5a, and 5b.

Graduate course, first semester, six hours per week Credit three hours.

21b. CYANIDING. *Lectures.* (Mann)

This course teaches the principles and practice of cyaniding. The student keeps up with the progress in the art. Attention is given in all the work to the cost of operation and to the schemes used and proposed for lessening the cost. A detailed study is made of the types of filter presses, crushing machinery, and other devices used in cyanide mills. Cyaniding is compared with other possible methods of treatment.

Prerequisites: Metallurgy 1b, 2b, and 3b.

Graduate course, second semester, four hours per week. Credit four hours.

22b. CYANIDE LABORATORY. (Mann)

The student in this course has an opportunity to test in the laboratory the methods discussed in the class room. The work is not routine, but the experiments are arranged to bring out a point under discussion, or to solve, if possible, the problems occurring at the time in the class room.

Prerequisites: Metallurgy 1b, 2b, and 3b. To accompany Metallurgy 21a.

Graduate course, second semester, six hours per week. Credit three hours.

23b. ORE SUPPLY. *Lectures.* (Copeland)

This course is intended to bring out the important subject of ore, flux, and fuel supplies. The subject is studied from a combined commercial and technical standpoint. The problems of valuing fluxes and fuels, of mixing ore so that the mixture shall command the lowest treatment rate, and of preparing, from the reduction works' standpoint, treatment charges for different classes of ores, are studied.

Prerequisites: Metallurgy 5a and 5b.

Graduate course, second semester, two hours per week. Credit two hours.

25a. METALLURGICAL RESEARCH. *Laboratory, Reading and Conferences.* (Clayton)

Each graduate student elects a subject for special study. It is recommended that the work be along a different line from the subject chosen for thesis. The course consists principally of assigned reading, together with conferences with the professor on the matter read. The laboratories are always open for the solving of any problem that may arise.

Prerequisites: Metallurgy 5a and 5b.

Graduate course, first semester, five hours per week. Credit five hours.

25b. METALLURGICAL RESEARCH. *Laboratory, Reading, and Conferences.*

This course is a continuation of Metallurgy 25a.

Prerequisite: Metallurgy 25a.

Graduate course, second semester, five hours per week. Credit five hours.

27b. ADVANCED METALLURGICAL PROBLEMS. *Lectures.* (Clayton)

This course has reference to the designing and proportioning of various types of furnaces for special duties and conditions.

Prerequisites: Metallurgy 13a.

Graduate course, second semester, one hour per week. Credit one hour.

29a. ALLOYS AND METALLOGRAPHY. *Lectures.* (Mann)

These lectures deal with the theoretical and practical consideration that influence the structure and properties of alloys of different types.

Prerequisites: Chemistry 7a, Metallurgy 3b.

Senior year, first semester, two hours per week. Credit two hours.

30a. ALLOYS AND METALLOGRAPHY. *Laboratory.* (Mann, Clayton)

This laboratory course is given in connection with the lectures, and deals chiefly with the micro-structure of iron and steel.

Prerequisites: Chemistry 7a, Metallurgy 3b.

Senior year, first semester, three hours per week. Credit 1.5 hours.

31b. ELEMENTS OF ORE DRESSING. *Lectures.* (Clayton)

In this course the principles of all common ore-dressing processes are briefly discussed. The various machines used for crushing, classification, and concentration of ores are described. Especial attention is given to those processes and mill schemes which the student has opportunity to see while on the Junior trip.

Prerequisites: Mathematics 15a, and Mineralogy and Geology 1b.

Required in I. and II.

Junior year, second semester, two hours per week. Credit two hours.

Text: Richards, *Textbook of Ore Dressing.*

33a. ORE DRESSING. *Lectures.* (Mann)

In this course the principles of mechanical ore treatment are discussed in detail. The construction and theory of machines are

presented in lectures, supplemented by a full equipment of models, which show the design of all common ore-dressing appliances. The latter part of the course deals with the management of mills and with the adaptation of processes to the successful treatment of various ores.

Prerequisite: Metallurgy 31b.

Senior year, first semester, five hours per week. Credit five hours.

Text: Richards, *Text book of Ore Dressing.*

33b. ORE DRESSING. *Lectures.* (Mann)

This course is a continuation of Metallurgy 33a.

Prerequisite: Metallurgy 33a.

Senior year, second semester, three hours per week. Credit three hours.

Text: Richards, *Textbook of Ore Dressing.*

34a. ORE DRESSING PROBLEMS. *Laboratory.* (Mann)

In this course advanced work is given in connection with the design of plants and machinery for the treatment of ores. The course includes the determination of a practical process for treating a given ore, and the design of a mill for utilizing this process.

Prerequisites: Metallurgy 1b, 2b, and 31b, Shop Practice and Drawing 2b. To be accompanied by Metallurgy 33a.

Senior year, first semester, three hours per week. Credit 1.5 hours.

36b. ORE DRESSING LABORATORY. (Mann, Clayton)

The student becomes familiar with the operation and care of milling machinery by actual laboratory experience. All types and classes of machines are available to illustrate principles and practice as presented in the lecture work. The laboratory is so arranged that a number of mill schemes may be utilized and processes for treating a particular ore can be determined from mill tests on large quantities of the ore.

Prerequisites: Metallurgy 1b, 2b, and 33a. To be accompanied by Metallurgy 33b.

Senior year, second semester, six hours per week. Credit three hours.

38. JUNIOR TRIP.

At the end of the school year the members of the Junior class make a three weeks' trip to Colorado and Utah, or other mining the study of the geology, mining and concentration of ores in the districts. The purpose of the trip is to give an opportunity for districts visited.

Credit may also be obtained for this trip in the following manner:

The student may obtain employment at any mine, mill, or smelter of his own selection, for a period of not less than six weeks. This work will be accepted as a substitute for the regular trip only when accompanied by a suitable report on the mining, metallurgy, and geology of the district in which he is employed. Outlines of these reports will be furnished by the various departments. Affidavits will be furnished the students to be signed by the mine or mill official, by whom he was employed, stating the time of such employment and nature of work.

Credit will be given for this course only to candidates for degrees of B. S. in Mining or Metallurgy.

Prerequisites: Metallurgy 3b, 31b, Mining 3b, Geology 3b.

Junior year, Summer session. Credit six hours towards Senior electives in I. and II.

39a. GENERAL METALLURGY. *Lectures.* (Clayton)

This course is an introduction for the advanced metallurgical courses. The work is covered in a general way by the following headings: The properties of metals; the chemical equation from the standpoint of the metallurgist; methods of combustion; the temperature of combustion in any system and the effect thereon of certain variables; measurement of high temperatures; means of supplying oxygen for combustion, including stack design; metallurgical fuels and methods of firing, including a study of coals, coke, charcoal, gases from producers, and liquid fuels; calorimetry; refractories and their uses; types of furnaces and the reasoning involved in their design; a general study of typical metallurgical operations including pyrometallurgical, hydrometallurgical and electrometallurgical processes; slags in general; conduction, radiation, and convection form the standpoint of the metallurgist. In this course much attention is given to the methods of attacking various metallurgical problems.

Prerequisites: Chemistry 3b and 4b, Geology and Mineralogy 1b.

Required in II.

Junior year, first semester, three hours a week. Credit three hours.

Texts: Fulton, *Principles of Metallurgy.*
Hofman, *General Metallurgy.*
Richards, *Metallurgical Calculations.*
Burgess and Le Chatelier, *The Measurement of High Temperature.*

39b. METALLURGY OF IRON AND STEEL. *Lectures.* (Clayton)

This course is intended for those intending to follow metallurgy. It takes up in detail the study of iron and steel and the work follows these general headings: The properties of iron and its alloys and compounds; specifications for standard irons and steels; the ores of iron and the principles underlying their valuation; the preparation of iron ores for the blast-furnace; the iron blast-furnace, its construction and operation; the manufacture of pig iron; the properties of pig iron, and the factors upon which these properties depend; the calculation of furnace charges; the chemistry of the blast furnace; the metallurgical operation of the blast furnace; blowing engines; utilization of furnace gases; treatment of flue dust; heat balance of the operation of a blast furnace; the manufacture of steels by the basic and acid bessemer, basic and acid open-hearth, crucible and, electric furnace methods; the manufacture of wrought iron; the constitution and structure of iron and steel; heat and mechanical treatment of steel; foundry practice; uses of steel products; and the study of special steels.

Prerequisites: General Metallurgy 39a.

Required in II.

Junior year second semester, three hours a week. Credit three hours.

Texts: Stoughton, *Metallurgy of Iron and Steel.*
Sauveur, *Metallography of Iron and Steel.*
Carnegie, *Liquid Steel.*
Howe, *Iron, Steel, and Other Alloys.*
Richards, *Metallurgical Calculations, Vol. II.*

MINING

Professor Forbes, Mr. Risher, and Mr. Cummings.

Equipment.

The mining lecture room, located on the first floor of Norwood Hall in the southwest corner of the building, is provided with a combination lantern, reflectoscope and moving-picture machine. The school has several hundred lantern slides of mining scenes and mining machinery, and motion films showing mining operations are obtained from the U. S. Bureau of Mines. Three rock drills in section, supported on a suitable frame, are kept in the classroom together with exhibits of explosives, rock drill bits, wire ropes, safety lamps, mine rescue apparatus and various other mining appliances.

A number of models illustrating mining methods, head frames, mine timbering, skip dumps, reversible mine fan, methods of locating drill holes in tunneling and rotary drill for coal mining, are on display in the mining laboratory and are used in connection with the lecture work.

The surveying equipment, already referred to under Civil Engineering, includes a number of mining transits with auxiliary telescopes which are used for the field work in mine surveying.

Laboratories.

To meet the needs of some of the more important phases of mining work, four laboratories have been equipped as follows:

Mine-Rescue and First-Aid Laboratory.

In accordance with the safety-first movement that has been making such rapid strides in the last few years, it has been deemed advisable to establish a mine-rescue and first-aid laboratory, where instruction is given in the use of breathing apparatus and in first aid to the injured. The equipment consists of three helmets, including a Draeger, Fleuss and Westfalia, a pulmotor, and all necessary first-aid supplies and charts. The time devoted to this laboratory does not exceed one afternoon a week for six weeks but this is sufficient to familiarize the student with mine-rescue apparatus and to give him a fair knowledge of the principles of first aid.

Rock-Drilling Laboratory.

On account of the importance of rock drilling in metal mining operations, and also because it can readily be carried on in the laboratory, much stress is laid on this branch of the work, for which the following equipment is used: Piston drills: Ingersoll-Rand 2 1-4 inch auxiliary-arc-tappet drill; Ingersoll-Rand C-110 Butterfly; Sullivan 2 3-4 inch tappet; Sullivan 2 1-4 inch differential-valve, with steam and air front heads; Sullivan FF-12 with water attachments; Wood 2 1-4 inch spool-valve. Hammer drills: No. 7 Water Leyner; Stopers: Waugh 16-V; Sullivan DA-21 with reverse feed; Hand Hammer Drills: Ingersoll-Rand Jack-hammer; Hardsocg; Cleveland.

This equipment has been purchased from time to time as improvements have been made by the manufacturers, and although not complete, embraces most of the different types of air drills in use at present. Later it is planned to purchase electric and gasoline drills.

For the work of drilling, large blocks of red granite about 4x4x5 feet are imported from southeast Missouri. Two drilling frames for supporting the machines on column and arm have been constructed,—one under cover in a frame building, and the other out of doors.

For sharpening steel, besides the usual hand tools, there is a Leyner-Ingersoll 5-A sharpener with a complete assortment of dies and dollies for forming various-shaped bits including the cross, X, Z, bull, five-point, six-point, eight-point, high-center and single and double-chisel bits, as well as parts for shanking Leyner, Jack-hammer and piston steels..

The work done in this laboratory consists in sharpening steel both by hand and with the sharpener, and in drilling with the various machines. No attempt is made to drill a great number of holes, but the work consists in measuring cutting speeds with different bits and air pressures, noting variations in length and number of strokes under varying conditions and measuring air consumption. For this purpose a Sullivan air meter is used, and an electrical device designed at the school is used for counting the number of blows of the drills.

The amount of time spent in the laboratory does not exceed three hours a week or one laboratory period for one semester in the regular course but much use is made of it in thesis and experimental work.

Compressed-Air Laboratory.

The use of compressed air is so important in mining operations that the school has deemed it advisable to equip this lab-

oratory with apparatus that would be suitable not only for students' use, but also for purposes of research and investigation.

A Sullivan WB-2 straight-line air compressor of 290 cubic feet capacity supplies air for this laboratory as well as the rock-drilling laboratory, and a Laidlaw-Dunn-Gordon compressor, used by the school in pumping from a deep well, is in the same building and furnishes a different type for study.

Two large displacement tanks 15 feet high and 5 feet in diameter are used for making accurate measurements of air for the determination of orifice coefficients and various other experiments. Another interesting installation in this laboratory is a mine-fan. This is a 36-inch single-inlet "Sirocco," directly connected to a 35 h. p. variable-speed motor, and has a capacity of 20,000 cubic feet per minute against a 4-inch water gauge. Two styles of runners with vanes at different angles are provided for experimental work. The fan is used in the regular laboratory work, where its efficiency is determined under varying conditions, and also for experimental work in air measurements, and the standardization of large orifices.

Mine Plant.

The mine plant is situated about one and one-half miles from the school, which was the nearest point available where rock of a suitable nature could be found. A tunnel is being driven into the hillside as shown in the engraving. The rock is a pitted dolomite.

The power plant for running the machine drills used in the tunnel consists of a 50 h. p. Erie fire-tube boiler and an Imperial type 10 Ingersoll-Rand air compressor of 100 cubic feet capacity. Water for the boiler is pumped from a nearby stream with a centrifugal pump driven by a small gasoline engine. A small engine and generator furnish power for lights and for running an electric drill.

In designing the power plant, an endeavor was made to introduce as great a variety of machinery as possible, as the operation of the plant is considered one of the most valuable features of this work.

The total time spent in the mine-plant laboratory is about the same as in the rock-drilling laboratory, but instead of working the usual three-hour period, from nine to twelve hours are put in at a time, as a three-hour period is entirely too short for this kind of work.

The work is largely experimental, and consists in using different explosives and analyzing their products of combustion; trying out different methods of placing holes for blasting and different methods of setting off blasts; time studies of drilling operations are made, and cost-records of the work are required. In addition to this, the work of sharpening steel, timbering, muck-

ing, track laying and hand drilling, together with the experience of running the power plant, affords a greater variety of work than can ordinarily be had in a reasonable length of time in practice. It is not the aim in this work to make drill runners or miners out of students, but to give them a greater familiarity with mining tools and methods than is obtainable from books or mere observation.

1a. MINING. *Lectures.* (Forbes)

An elementary course in mining designed to acquaint the student with the mining industry and mining districts. Mining methods are reviewed in an elementary way, in order to familiarize the student early in his course with the different phases of mining operations. Lantern slides and moving pictures are used profusely in this work.

Prerequisites: Entrance requirements.

Required in I., II., III., and IV.

Freshman year, first semester, two hours per week. Credit two hours.

3a. MINING. *Lectures.* (Forbes)

A study of rock excavation including: rock drilling, explosives and blasting, supporting excavations, tunneling and shaft-sinking. Written reports are required on each subject as completed.

Prerequisites: Mining 1b, Mechanical Drawing 2b.

Required in I. and III.

Sophomore year, first semester, three hours per week. Credit three hours.

Texts: Foster, *Ore and Stone Mining.*
Donaldson, *Shaft Sinking.*
Storms, *Timbering and Mining.*
Weston, *Rock Drills.*
Current Technical Journals.
Publications of U. S. Bureau of Mines.

5b. MINE SURVEYING. *Lectures.* (Forbes, Risher)

The theory and practice of mine surveying are presented by lectures. The methods of carrying azimuth underground under different conditions are studied in detail, including shaft plumbing and the use of the auxiliary telescope. Notes of a complete mine survey are given the student, from which all calculations must be made and maps drawn. Other problems involving the strike and dip of veins are introduced, including the determination of intersection of veins, length of tunnels to intersect veins at depth, and the determination of strike, dip and thickness of veins from bore hole data.

Prerequisite: Civil Engineering 2a.

Required in I.

Sophomore year, second semester, two hours per week. Credit two hours.

Text: Durham, *Mine Surveying.*

6. MINE SURVEYING. *Laboratory.* (Forbes, Risher)

A mine surveying trip to Joplin or other mining districts is a required part of the work of the Sophomore year. In this course the student is given an opportunity to do mine surveying under actual mining conditions. The course lasts from one week to ten days, depending on the ability of the student, who is required to make a correct survey and map of a certain part of a mine. Credit three hours.

Prerequisite: Mining 5b.

Required in I.

6b. MINE SURVEYING. *Laboratory.* (Forbes, Risher)

One afternoon per week is devoted to the solution of problems in mine surveying and to make mine maps.

Prerequisite: Must be accompanied by Mining 5b.

Required in I.

Sophomore year, second semester, three hours per week. Credit one and one-half hours.

10. PRACTICAL MINING. (Forbes)

In order to stimulate interest in practical mining, the mining department offers the following plan by which credit may be obtained for such work.

The student must spend at least three weeks in the study of mining operations, at some mine designated by the Department, taking notes, making sketches, and observing details of mining operations.

Instead of the above work, the student may obtain employment at any time of his own selection, which is acceptable to the department, for a period of not less than six weeks, four weeks of which must be spent in underground work. This work will be accepted as a substitute for the above only when accompanied by a satisfactory report, an outline of which will have been given to the student in advance.

Credit may be obtained for the above work by submitting the report as a thesis, if approved by the thesis committee, and also some credit may be allowed toward the Junior and Senior mining laboratories for equivalent work, at the discretion of the mining department.

All reports on Summer Practical Mining must be presented to the department not later than September 15th.

Prerequisites: Mining 3a and 5b.

No credit will be allowed for Practical Mining unless followed by courses 11b Mining and 15a and 16b Mining Machinery.

Junior year, Summer session.

11b. MINING. *Lectures.* (Forbes)

This is a continuation of the work of the Sophomore year, and includes the study of mining methods, sampling and estimation of ores, mine valuation, and a study of mining costs. The principles of mining law are also reviewed.

Candidates for the degree of Bachelor of Science in Mine Engineering or Metallurgy taking this course must also take the mining part of Course 12, Senior Trip.

Prerequisites: Mining 3a, Geology 9a.

Required in I.

Senior year, second semester, three hours per week. Credit three hours with senior trip; two and one-half hours without trip.

Texts: Hoover, *Principles of Mining.*
Finlay, *The Cost of Mining.*
Current Technical Journals.

12. SENIOR TRIP.

During the second semester of the Senior year, a three weeks' trip is taken to Joplin, St. Louis, Flat River, and other points in the Southeast Missouri Lead District, for the purpose of studying the Mining Ore Dressing, Smelting, Geology, and Power Plants of these districts. The mining part of this trip is required of all candidates for degrees in Mining Engineering and Metallurgy who take Course 11b, Mining.

Prerequisite: Mining 11b.

Required in I.

Senior year, second semester.

13. MINE VENTILATION. *Lectures.* (Risher)

A study of the various gases met with in mines, their origin, effects and detection; the amount of fresh air required for men and animals under varying conditions; natural and artificial means of ventilation; gas and dust explosions, and mine rescue work. A large part of the course is devoted to problems in mine ventilation.

Prerequisites: Mining 3a and Physics 3a.

Junior year, second semester, two hours per week. Credit two hours.

15a. MINING MACHINERY. (Forbes)

An advanced study of rock drills and compressed air machinery. Haulage and hoisting machinery, pumps, and ventilating fans are also studied in this course.

Prerequisites: Mining 3a and 16a, and Physics 5a; must be accompanied by Civil Engineering 27a, Compressed Air, and Mining 16a.

Senior year, first semester, two hours per week. Credit two hours.

16a. MINING LABORATORY. (Forbes, Cummings)

Laboratory work in rock drilling and blasting, timbering, sharpening steel, track-laying, and operation of mine power plants. Reports are required on all work. A study of mine rescue apparatus and first-aid to the injured is included in this course.

No credit will be allowed in mining laboratory except in Curriculum I.

Prerequisite: Mining 3a.

Required in I.

Junior year, first semester, three hours per week. Credit one and one-half hours.

16b. MINING LABORATORY. (Forbes, Cummings)

A continuation of the laboratory work of the Junior year. A feature of this work is the keeping of accounts and cost records of tunnel driving as a training in the study of mine accounting.

No credit will be allowed in mining laboratory except in Curriculum I.

Prerequisites: Mining 3a, 15a and 16a; Civil Engineering 27a; must be accompanied by Mining 17b.

Senior year, second semester, three hours per week. Credit one and one-half hours.

17b. MINING CONFERENCE. *Lectures.* (Forbes)

The conference consists in discussions relative to the mining laboratory work and lectures on mine accounting and book-keeping. Reports are prepared by the student on various assigned subjects and presented to the class.

Prerequisites: Must be accompanied by Mining 16b.

Senior year, second semester, one hour per week. Credit one hour.

19a. MINING ECONOMICS. *Lectures.* (Forbes)

Various economic problems of interest to mining engineers are studied. The influence of mining in the history of America

and especially in United States history is reviewed and the relation of mining to other industries is considered. The organization of the mining industry, the conservation of the mineral resources, and various problems in economics, including mining labor, wages, capital, taxation, profit-sharing, and employers' liability are presented by lectures and assigned reading.

Prerequisites: Mining 11b, Geology 9a.

Graduate course, first semester, one hour per week. Credit one hour.

20a, 20b. MINE PLANT DESIGN. *Laboratory.* (Forbes)

This is a drafting-room course and is supplementary to all the previous mining courses. Each student is required to prepare complete drawings for the equipment of a given mine. Bills of material, specifications, and complete estimates are submitted.

Prerequisites: Mining 11b and Civil Engineering 15a.

Graduate course, first and second semesters, six hours per week. Credit six hours.

21a. COAL MINING. *Lectures.* (Forbes)

A detailed study of coal mining, including methods of mining, coal mining machinery, haulage problems and design of shaft bottoms, and coal washing.

Prerequisite: Mining 13b.

Senior year, first semester, three hours per week. Credit three hours.

21b. MINING. *Lectures.* (Forbes)

Methods of prospecting, sampling and estimation of ore bodies and mine valuation are studied by lectures and assigned readings.

Prerequisite: Geology 9a.

Senior year, second semester, two hour per week. Credit two hours.

Text: Rickard, *Sampling and Estimation of Ores.*
Herzig, *Mine Sampling and Valuing.*

23a. MINING LAW. *Lectures.* (Forbes)

A study of the mineral land laws of the United States and laws affecting the operation of mines, including workmen's compensation acts.

Prerequisites: Completion of the Junior year in Curriculum I.

Senior year, first semester, one hour per week. Credit one hour.

25b. OIL AND GAS. *Lectures.* (Forbes)

A study of well drilling and oil production methods.

Prerequisite: Geology 17a

Senior year, second semester, one hour per week Credit one hour.

Text: Paine and Stroud, *Oil Production Methods.*

38. JUNIOR TRIP.

At the end of the school year the members of the Junior Class take a three weeks' trip to Colorado and Utah, or other mining districts. The purpose of the trip is to give an opportunity for the study of the geology, mining, and concentration of ores in the districts visited.

Credit may also be obtained for this trip in the following manner:

The student may obtain employment at any mine, mill, or smelter of his own selection, for a period of not less than six weeks. This work will be accepted as a substitute for the regular trip only when accompanied by a suitable report on the mining, metallurgy, and geology of the district in which he is employed. Outlines of these reports will be furnished by the various departments. Affidavits will be furnished the students to be signed by the mine or mill officials, by whom he was employed, stating the time of such employment and nature of work.

Credit will be given for this course only to candidates for degrees of B. S. in Mining or Metallurgy.

Prerequisites: Mining 5b, Geology 3b, and Metallurgy 31b.

Junior year, Summer session. Credit six hours toward Senior electives in I. and II. Credit for mining part of trip two hours.

PHYSICS

PROFESSOR MCRAE, MR. FRAME, MR. DUFFY, MR. ADAMS.

Equipment.

The lecture room and laboratories for Physics and Electricity are in Norwood Hall. The lecture room will seat one hundred students and is provided with water, gas, and electric connections for conveniences in lecture demonstrations and experiments.

The physical laboratory is on the ground, or basement, floor. There are two large laboratories, one equipped for general physical measurements in mechanics, sound, and heat, and one equipped for electric measurements. There is a battery room equipped with both primary and secondary batteries by wire with the various laboratories and the lecture room; a constant-temperature room with double walls and air space insulation; a commodious dark-room with blackened walls for spectrometric and photometric measurements and a special laboratory for research work.

The equipment includes a Rowland electro-dynamometer with shunts and resistances; a Leeds and Northrup standard potentiometer with shunts and voltage coils; a Leeds and Northrup decade wheatstone bridge; a Queen post office pattern wheatsone bridge; a Leeds and Northrup ohmmeter; various wheatstone bridges and resistance boxes; standards of resistance and inductance; paper and mica condensers; various tangent, mirror, and ballistic galvanometer; a Duddell thermo-galvanometer; a Dolezalek quadrant electrometer; a Lummer-Brodhun photometer; a Bunsen photometer; a Gaetner dividing engine with linear and circular attachments; a Threlfall micro-manometer; a Dietzgen anemometer; a ten-inch induction coil; Crookes tubes; cathode and X-ray tubes; a Van Hooten and Tenbroeck electrostatic machine; a wireless demonstration set; a Gaetner electroscope for radio-active measurements; a Schmidt & Haensch spectrometer; a Rowland diffraction grating; photographs of Rowland's normal solar spectrum; an Ives photograph of a Rowland grating; various balances; calorimeters; micrometers, calipers, together with apparatus for illustrating the principles of physics.

The steam laboratory equipment includes Parr and Roland-Wild coal calorimeters; Ellison throttling and evaporating moisture calorimeter; Peabody, and Schaeffer and Budenberg moisture

calorimeters; General Electric Co., and Gebhardt portable steam flow meters; Hays, and Orsat flue gas apparatus; Crosby, Thompson, Robertson, Schaeffer and Budenberg, and American steam and gas engine indicators; Schaeffer and Budenberg continuous drum indicator; Amsler, Willis, and Keuffel and Esser planimeters; various indicating and recording steam gages; Crosby steam gage tester; Tycos portable pyrometer; three water meters; thermometers, manometers, tachometers and speed counters; Prony and friction brakes.

The dynamo laboratory contains an assortment of direct current generators and motors, a General Electric double current generator for direct current and alternating current work, a single and a three-phase generator, an induction motor, a single-phase repulsion motor, a rotary converter, stationary transformers, three-phase to two-phase transformers, Cooper-Hewitt mercury converters, a General Electric electrolytic motor-generator set, a remote control starting box, testing instruments, which include a Weston laboratory standard voltmeter with multipliers; a Weston laboratory standard millivoltmeter with shunts; Kelvin electrostatic stationary and portable voltmeters; Weston portable ammeters and voltmeters; Weston portable milli-voltmeters with shunts and milliammeters with resistances; Weston, Thompson, and Westinghouse portable direct current and alternating current voltmeters; Weston and Thompson portable watt meters; Westinghouse portable polyphase wattmeter; Westinghouse portable single and polyphase watt-hour meters; Westinghouse portable voltmeters and ammeters with transformers; General Electric edgewise type alternating current voltmeters, ammeters and watt-hour meters; electrodynamometers; Grassot fluxmeter; portable resistance grids, inductance coils, and condensers.

The various electrical motors used for power purposes in the shops and laboratories are available for testing in addition to the machinery in the dynamo laboratory. The total electrical equipment includes thirty-five motors, varying in size from ½ h. p. to 35 h. p., with the aggregate rating of 225 h. p.

The power plant is also used for experimental purposes, and comprises a strictly modern and thoroughly equipped laboratory. The machinery available for testing purposes includes four 130-h p. Heine safety boilers, one of which is especially equipped with openings in the setting for temperature and draft measurements in furnace, combustion chamber and flues; a 13 by 14 Erie Ball engine direct connected to a 75 kw. 220 volt D. C. Westinghouse generator; a 10 by 12 Ideal engine direct connected to a 50 kw. 220 volt D. C. Westinghouse generator; a 12 by 11 General Electric marine type engine direct connected to a 50 k. v. a. 220 volts, 60 cycle, three phase generator with direct connected exciter; a 10 kw. 220 volt Curtis steam turbo generator; a 9 by 14 Brownell

engine equipped with a rope friction brake; a 5 by 7 Davis and Rankin vertical engine equipped with a Prony brake; a 21-h. p. Otto four strokes per cycle gas engine belted to a General Electric 15 kw. 220 volt D. C. interpole generator, and to a two stage Worthington centrifugal pump; a 3-h. p. Ferro two strokes per cycle portable gas engine; a D. C. switchboard with a panel for each generator and two for distribution switches, equipped with a Tirrill voltage regulator, a Thompson recording watt-hour meter, circuit breakers for each generator, and the usual ammeters and voltmeter; an A. C. Switchboard with volt-meter, ammeters, wattmeter, and watt-hour meter. The pneumatic equipment includes a Laidlow-Dunn-Gordon air compressor, a Rand Imperial air compressor, a Sullivan straight-line two-stage air compressor, a 72-inch ventilating fan, a 36-inch ventilating fan, a 60-inch Buffalo forge blower, an experimental fan capable of delivering 250 cu. ft. of air per second at six inches of water pressure, two cylindrical steel tanks 6 ft. by 15 ft. for measuring air by water displacement.

There is a complete steam and pumping plant at the experimental mine, where laboratory practice is also obtained.

Courses.

1b. GENERAL PHYSICS. *Lectures.* (McRae, Frame)

The work in general physics begins with the study of kinematics, statics, kinetics, and the mechanics of fluids. The term's work concludes with the study of heat, including an introduction to thermodynamics. Particular attention is paid to harmonic motion as the basis for the study of such subjects as sound, light, and alternating currents of electricity.

Prerequisites: To be preceded by or accompanied by Mathematics 9a, 11a and 11b.

Required in I., II., and III.

Sophomore year, second semester, four hours per week. Credit four hours.

Text: Duff, *A Text-Book of Physics.*

2b. GENERAL PHYSICS. *Laboratory.* (Frame)

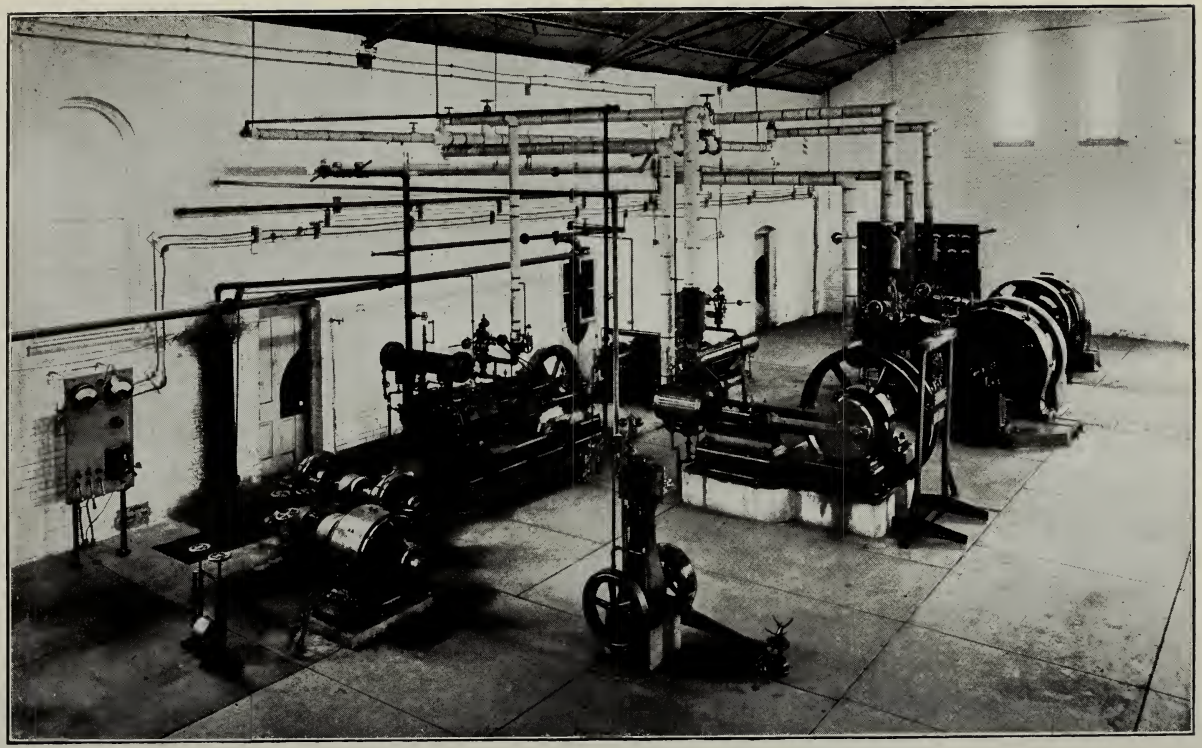
The laboratory is quantitative, and aims, as far as possible, to instruct the student in the methods of physical measurement and the derivation of relations between the quantities measured. Emphasis is laid upon the derivation of physical laws rather than the verification of them.

Prerequisite: Mathematics 7b.

Required in I., II., and III.

Sophomore year, second semester, three hours per week. Credit one and one-half hours.

MECHANICAL HALL



STEAM LABORATORY

3a. GENERAL PHYSICS. *Lectures.* (McRae, Frame.)

This is a continuation of course 1b and includes the study of electricity and magnetism, sound and light. Particular stress is laid upon electrical potential, resistance, and impedance, and upon the reflection, refraction, and interference of waves. Lectures, illustrated by experiments, and recitations.

Prerequisites: To be preceded by or accompanied by Mathematics 9a and 11a.

Required in I., II., and III.

Junior year, first semester, four hours per week. Credit four hours.

Text: Duff, *A Text-book of Physics.*

4a. GENERAL PHYSICS. *Laboratory.* (Frame)

The work in the laboratory deals with the subjects studied in Physics 3a and the method is the same as that outlined in Physics 2b.

Prerequisite: To be accompanied by Physics 3a.

Required in I., II., and III.

Junior year, first semester, three hours per week. Credit one and one-half hours.

5a. THERMODYNAMICS. *Lectures.* (McRae)

A short course in theoretical thermodynamics is followed by a study of boilers, furnaces, and heat engines, standard types of safety and tubular boilers, chimney and mechanical draft, pumps and heaters. Steam, gas, and gasoline engines are also studied.

Prerequisites: Mathematics 9a and 11a, and Physics 1b.

Required in I., II., and III.

Junior year, first semester, three hours per week. Credit three hours.

Texts: Cardullo, *Heat Engines.*
Marks and Davis, *Steam Tables.*

6a. STEAM LABORATORY. (McRae, Adams)

Practice is had in operating and indicating steam and gas engines, measuring chimney draft, combustion products, moisture in steam, furnace temperatures, and the calorific value of fuels.

Prerequisite: To accompany Physics 5a.

Required in I., II., and III.

Junior year, first semester, three hours per week. Credit one and one-half hours.

7a, 7b. ELECTRICAL MACHINERY. *Lectures.* (Duffy)

This course discusses the magnetic circuit of dynamos and motors, methods of testing and connections for operation of direct

current dynamos and motors, of single and polyphase alternating current generators, of induction and synchronous motors, of stationary transformers and rotary converters, and the effects of frequency, resistance, inductance and capacity upon the impedance of alternating current circuits. During the latter part of the course, the design of electrical transmission lines is studied, accompanied by the analytical and graphical solution of practical problems.

Prerequisites: Physics 1b and 3a.

Senior year, elective, first and second semester, three hours per week. Credit six hours.

Texts: Gray, *Principles and Practice of Electrical Engineering.* Pender, *Principles of Electrical Engineering.*

8a, 8b. DYNAMO LABORATORY. (McRae, Adams)

This course accompanies course accompanies course 7a, 7b, and consists of calibration of instruments, measurements of ohmic and reactive resistances, insulation resistance and dielectric strength, regulation and efficiency tests, of dynamos, motors, transformers, and converters.

Prerequisites: Physics 1b and 3a.

Senior year, elective, first and second semesters, three hours per week. Credit three hours.

9a, 9b. ELECTRICITY AND MAGNETISM. (Frame.)

This course is designed as an introduction to the study of electricity and magnetism.

Prerequisite: Mathematics 3a.

Elective, first semester, lectures and recitations, five hours per week. Credit five hours.

Second semester, four recitations per week. Credit four hours.

Text: Timbie, *Elements of Electricity.*

10b. ELECTRICAL LABORATORY. (Frame)

This course includes elementary tests in electrical and magnetic circuits, measurements with ammeters, voltmeters and wattmeters, and practice in wiring connecting up lamps, motors and transformers.

Prerequisite: Physics 3a or 9a.

Sophomore year, second semester, six hours per week. Credit three hours.

13a, 13b. ALTERNATING CURRENTS. (McRae)

A continuation of Physics 11b and includes a rigorous analytical treatment of the subject as well as a study of the various practical applications in mining and metallurgy.

Prerequisites: Physics, 7b and 8b.

Elective, first and second semesters, five hours per week. Credit ten hours.

Text: D. C. and J. P. Jackson, *Alternating Currents and A. C. Machinery.*

15b. INTERNAL COMBUSTION ENGINES. (McRae)

This course includes the theory of internal combusion engines, as well as their practical application in mining operations and in metallurgical industries.

Prerequisites: Physics 5a and 6a.

Graduate course, second semester, three hours per week. Credit three hours.

16b. POWER PLANT TESTS. *Laboratory.* (McRae, Adams)

This course is a continuation of Physics 6a and consists of tests on power plants and conferences on mining power plants.

Prerequisite: Physics, 6a.

Senior year, second semester, three hours per week. Credit one and one-half hours.

17b. MINE POWER PLANTS. *Lectures.* (McRae)

This course comprises a study of the types of engines, boilers, hoists, and machinery used in mine power plants together with their lay out and operation.

Prerequisites: Physics 5a, 6b.

Senior year, elective, second semester, two hours per week. Credit two hours.

Text: Gebhardt, *Steam Power Plant Engineering.*

SHOP PRACTICE AND DRAWING

Assistant Professor Bowen, Mr. Duffy, Mr. Bock, Mr. Wood, Mr. Gammeter, Mr. Dunham.

Equipment.

The shops are thoroughly equipped with machinery and benches adapted to instruction The wood bench work room contains twenty double benches with separate sets of hand tools. The lathe room is equipped with twenty Fay & Egan 12-in. swing college wood lathes with iron shears. The other machines in the lathe room include a Fay & Egan 27-in. planer, a Fay & Egan band saw with 30-in. wheels, an Oliver universal saw-table, two Oliver wood trimmers, a mortise machine, jig saw, grindstone, and other necessary tools.

For instruction in forge work there are twenty-four Buffalo Forge Company down-draft forges, power hammer, drill press, power shears, and grinder.

The metal-working room contains:

One 20-in. by 8-ft. Reed Lathe.
One 12-in. by 6-ft. Reed Lathe.
One 14-in. by 6-ft. Hendey Lathe.
One 14-in. by 6-ft. American Lathe.
One No. 2A Brown & Sharpe Universal Milling Machine.
One Hendey 15-in. Pillar Shaper.
One Dwight Sensitive Drill.
One Barnes 22-in. Swing Upright Drill Press.
One 24-in. Morse Double Emery Grinder.
One 24-in. by 24-in. by 6-ft. Chandler Planer.
Two Greenard Arbor Presses, No. 3½ and No. 1.
One No. 1 Burr Cold Saw.
One 3-fire Chicago Flexible Shaft Gas Furnace.

All of the above mentioned iron-working machinery is of latest design and driven by individual motors. The benches in the lathe room have hardwood tops mounted on standard Brown & Sharpe bench legs. Twenty-four machinist vises, twelve of which have the swivel base and jaw, equip the shop for bench work.

The drawing rooms are equipped with individual drawing tables and will accommodate two hundred and forty students working in two sections.

Courses.

1a. DESCRIPTIVE GEOMETRY. *Lectures and Problems.* (Duffy)

The usual text-book work is reinforced with blackboard exercises in presenting the projections of familiar objects, intersections of plane and curved surfaces, sections, developments, and shades and shadows. The afternoons in the drawing room are spent in solving in neat form more elaborate exercises.

Prerequisites: Entrance requirements.

Required in I., II., III and IV.

Freshman year, first semester, three hours per week. Credit three hours.

2a. MECHANICAL DRAWING. *Laboratory.* (Duffy, Gammeter)

The student is first given practice in geometrical construction until he is familiar with the nature, care and use of drafting instruments. Then, after carefully studying the principles of orthographic projection, intersection, and development, he is thoroughly drilled in free-hand lettering. The course is completed with one term of machine drawing. In this the student is required to make sketches, detail and assembly drawings of machines, and is taught the principles of elementary machine design.

Prerequisites: Entrance requirements.

Required in I., II., III., and IV.

Freshman year, first semester, six hours per week. Credit three hours.

Text: *French, Engineering Drawing.*

2b. MECHANICAL DRAWING. *Laboratory.* (Duffy, Gammeter)

A continuation of Shop Practice and Drawing 2a.

Prerequisites: Shop Practice, Drawing 2a and Descrip. 1a.

Required in I., II., III., and IV.

Freshman year, second semester, six hours per week. Credit three hours.

4a. MACHINE DRAWING. *Laboratory.* (Duffy)

This course is a continuation of the work in mechanical drawing of the Freshman year. It includes exercises covering gearing, power transmission, mechanism, and the simpler machines used in mining, ore dressing and metallurgy.

Prerequisite: Shop Practice, Drawing 2b and Descrip. 1a.

First semester, six hours per week. Credit three hours.

4b. MACHINE DRAWING. *Laboratory.* (Duffy)

This course is a continuation of Shop Practice and Drawing 4a.

Prerequisite: Shop Practice, Drawing 4a and Descrip. 1a.

Sophomore year, second semester, six hours per week. Credit three hours.

5a. MACHINE DESIGN. *Lectures and Laboratory.* (Duffy)

Problems involving the relations of the different parts of a machine. Their individual shapes and strengths are studied. The student is required to present his work in the form of working drawings with calculations and written description of the parts.

Prerequisites, Shop and Drawing 4b and Mathematics 19b.

Senior year, first semester, two lectures and six hours laboratory. Credit five hours.

12a. WOOD WORK. *Laboratory.*

(Bowen, Bock, Dunham, Wood)

The work in the wood shop aims to train the student in the use of wood-working tools and machinery and to familiarize him with the properties of the common woods. All work is done from drawings.

Prerequisites: Entrance requirements.

Required in I., II., III., and IV.

Freshman year, first semester, six hours per week. Credit three hours.

14b. FORGE WORK. *Laboratory.*

(Bowen Bock, Dunham, Wood)

This course begins with simple exercises in drawing, upsetting, bending, twisting, punching, and welding. The work gradually becomes more difficult, such as making eye-bolts, chains, and tongs. Tool making is then begun by making screw-drivers, hammers, chisels, and a complete set of lathe tools to be used later in the machine shop. This work is fully illustrated by drawings and lectures on the subject, covering the properties of the different grades of iron and steel. The instructors make the student familiar with the best grade of steel to be used for any required purpose, and the correct shape and temper necessary for the best work in cutting iron, steel, brass and stone. The final and most important part of this work is the testing of rock-drills on different grades of steel used.

Prerequisite: Shop Practice and Drawing 12a.

Required in I., II., III., and IV.

Freshman year, second semester, six hours per week. Credit three hours.

16a. FORGE WORK. *Laboratory.* (Bowen)

This course is a continuation of Shop Practice and Drawing 14b.

Prerequisite: Shop Practice and Drawing 14b.

Junior year, first semester, six hours per week for eight weeks. Credit one and one-half hours.

18a. MACHINE SHOP. *Laboratory.* (Bowen, Cole)

This course begins with chipping to a line, filing to a dimension, and scraping to a surface plate. Machine operation is then begun; the principles and uses of the drill-press, lathe, planer, shaper, and milling machines are taught by lectures followed by practical work at each machine. After a reasonable time, skill is attained in operating the various machines through a course of graded exercises. In this work use is made of the vernier, micrometer, thread-micrometer, and gear tooth caliper. Entire machines are also built, such as Lathes, Gasoline Engines, Wood Trimmers, etc., etc. The degree of accuracy thus acquired enables the student to use eye and hand in unison, and is a lasting benefit in teaching exactness in statement and measurement.

Prerequisite: Shop Practice and Drawing 16a.

First or second semester six hours per week. Credit three hours.

PHYSICAL TRAINING

Associate Proressor Dennie.

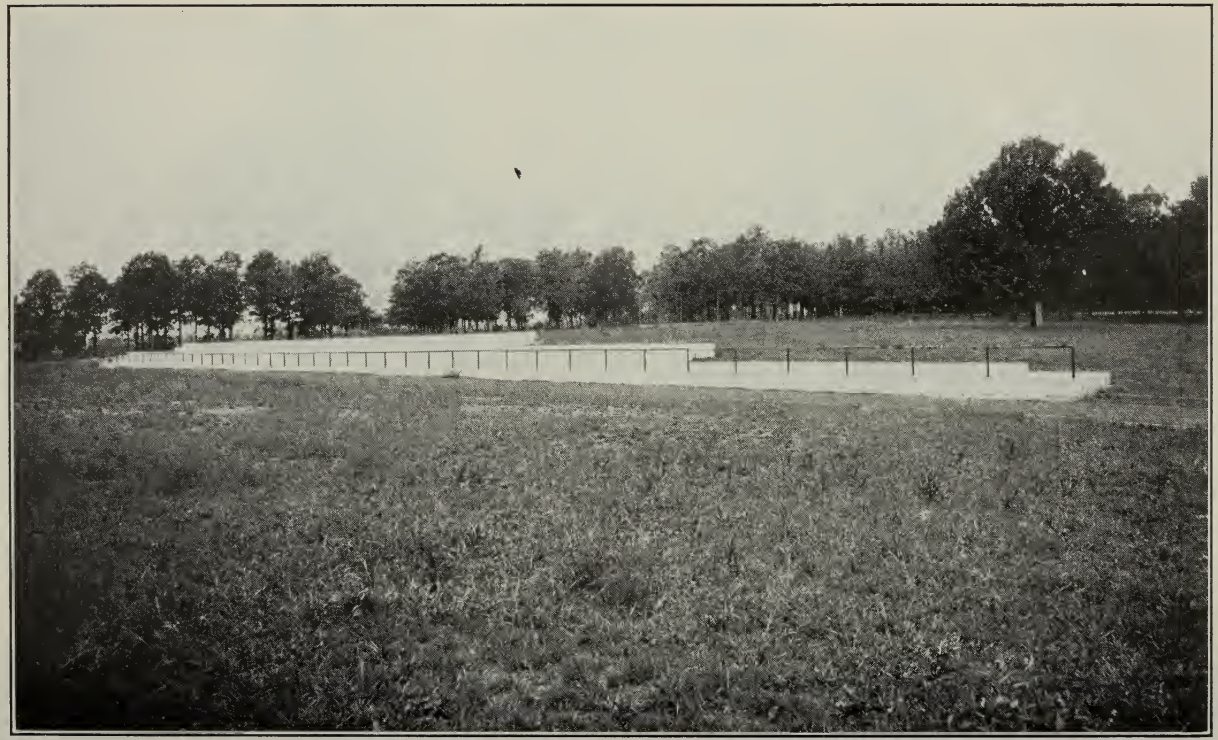
Jackling Athletic Field and the new gymnasium offer opportunities for the physical training of students.

The field, constructed by virtue of a gift of Mr. D. C. Jackling, '92, was first used in 1909 and provides a football gridiron, a baseball diamond, and quarter-mile running track for class and intercollegiate games and events. A number of tennis courts have been laid out and are maintained in good order.

The Forty-seventh General Assembly made an appropriation of seventy thousand dollars for a fireproof gymnasium. This contains the usual gymnasium equipment and provides for as many indoor sports as possible. It contains a swimming-pool, showers, lockers, etc.

All branches of athletics are under the supervision of the Athletic Director and are managed by the Board of Control, which consists of a member of the Faculty, an undergraduate, and the Professor of Physical Training.

SOUTH GATE—CAMPUS VIEW



BLEACHERS—ATHLETIC FIELD

EXCURSIONS

The State of Missouri occupies an important place in the mining industry, leading in the production of lead, zinc, cobalt, nickel, barite, and tripoli. Many opportunities are offered students at the School of Mines and Metallurgy for keeping closely in touch with the mining industry of Missouri and adjoining States. There have been many important developments during the last few years in methods of mining, dressing, and smelting lead and zinc ores. The lead district of Southeast Missouri and the zinc district of Southwest Missouri offer numerous examples of up-to-date practice in mining and metallurgical engineering. The aggregate tonnage capacity of the concentrating plants of Missouri is greater than that of any other state of the Union. The importance of modern methods of ore dressing is everywhere recorgnized, and the facilities offered by the School of Mines for investigation in ore dressing, together with the practice in concentrating plants which are visited, places the School of Mines and Metallurgy in the foremost rank in this important branch of mine engineering.

During the summer the Junior class makes a trip to Colorado and Utah, visiting Denver, Idaho Springs, Central City, Georgetown, Silver Plume, Montezuma, Breckenridge, Leadville, Colorado Springs, Cripple Creek, Victor, and Pueblo in Colorado, and Salt Lake City, Garfield, and Bingham in Utah. Special attention is given to mining practice in the Clear Creek District, the Cripple Creek District, and Leadville and vicinity. Amalgamation is studied in the Clear Creek District; cyanidation at Colorado Springs and Victor; smelting of gold, silver, copper, and lead ores at Leadville and Pueblo; iron and steel metallurgy at Pueblo; treatment of zinc ores at Leadville.

Special attention is paid on these trips to general engineering problems, plant design, economy of operation, and organization.

During the Senior year a trip is made to the metallurgical plants in the vicinity of St. Louis. The plant of the St. Louis Blast Furnace Company illustrates blast-furnace practice. Here may be studied the blast-furnace, regenerative stoves, blowing machinery, power plant, and other appliances necessary for the production of pig iron. Open-hearth steel methods and the manufacture of steel castings are studied at the Scullin & Gallagher Works. This plant includes, in addition to the usual type of open-hearth furnace, Bessemer converters, cupolas, and gas-producers.

The metallurgy of zinc is studied at the Edgar Zinc Works at

Carondelet, where the roasting of blende and distillation methods may be seen. The Federal Smelter, at Alton, is visited for the study of lead smelting. At this plant the lead blast-furnace, the Huntington-Heberlin roasting system, and the Scotch ore-hearths are carefully inspected. This plant also includes an extensive bag house. The manufacture of white-lead paint and of lead pipe is seen at the National Lead Works. A further study of lead smelting is made at Herculaneum, where blast-furnaces are served by Savelsberg pot roasters. At the various plants enumerated particular attention is paid to construction of furnaces, the operation of the plant, and the general organization and design.

The manufacture of refractory materials is carefully followed from the mine to the finished product at the plant of the Laclede-Christy Company. This plant is one of the largest clay manufacturing works in the world and a metallurgist here has a splendid opportunity to investigate refractory products and materials used in the construction of furnaces, stacks, retorts, and crucibles.

The class visits Southeast Missouri to study the geology, methods of mining, and the milling of great disseminated lead deposits. The geological work of this trip is especially valuable because of the variety of work introduced. The class has an opportunity to study several varieties of pre-Cambrian rocks of igneous and other origin. Differentiation in magma and intrusions can be seen. The pre-Cambrian topography is discernible in relation to the contact plane between the pre-Cambrian and the Cambrian. Evidence of superimposed drainage is offered. Iron ores of Shepard Mountain, Pilot Knob, and Iron Mountain give interesting study in the distribution and origin of ores. The general relation of the lead ores of the Paleozoic is also studied. The weathering of various kinds of rock in conjunction with jointing and stratification is well illustrated.

The concentrating plants of Southeast Missouri are large and modern, containing crushers, rolls, elevating machinery, Wilfley tables, Frue vanners, jigs, and sundry other machines. The mining plants are thoroughly modern and include steam and electric hoists, modern steel head-frames, compressed air and electric haulage, extensive pumping plants, and numerous diamond-drill prospecting equipments.

In Southwest Missouri the geology, mining and milling of the shallow deposits as well as of "sheet" ground are studied by the Seniors. Opportunity is given to inspect and study the various types of equipment and methods as adapted to shallow and deeper mining. Many new concentrating plants have been erected and are strictly modern in design and equipment. The application of electrical power to mining and milling is well illustrated in this district. Short trips are made to neighboring camps in Southwestern Kansas.

Required.

A. At the close of the sophomore year a two-weeks' trip for mine surveying. This work is usually done in the coal mines adjacent to St. Louis.

Required of all candidates for the degree of Bachelor of Science in Mine Engineering.

B. At the opening of the Junior year, one week's work in topographic surveying. This work is done in the vicinity of Rolla.

Required of all candidates for the degree of Bachelor of Science in Mine Engineering.

C. A three weeks' trip to various points in Missouri during the second semester of the Senior year. The points usually included in this trip are St. Louis, Herculaneum, Crystal City, the Flat River district, Iron Mountain, and the Joplin district.

Required in connection with the Senior courses in Mining, Geology, Metallurgy, and Power Plant, of all candidates for degrees in Mining or Metallurgy.

Elective.

D. A three weeks' trip to Colorado or Utah, or other mining districts at the close of the Junior year for the study of Mining, Metallurgy, Ore Dressing and Geology.

GENERAL INFORMATION

STUDENT ORGANIZATIONS.

The following chapters of college fraternities exist at the School: Gamma Chi of Sigma Nu, Beta Alpha of Kappa Alpha, Beta Chi of Kappa Sigma, Alpha Kappa of Pi Kappa Alpha, and Missouri Beta of Tau Beta Pi.

The Young Men's Christian Association was organized in the College several years ago, and is growing rapidly. It stands for the best there is in college life and brings together those who believe that college men should develop well-rounded characters, physical, mental, and spiritual. During the opening days of the College trains are met by Association members, who place themselves at the service of the new men, helping them to secure rooms and board and to matriculate. The Association occupies quarters on the second floor of Norwood Hall, where all students are welcomed and regular meetings are held.

Students of the School of Mines maintain a Mandolin Club and an Orchestra.

A student annual, called "The Rollamo," is published by the student body. The purpose of this volume is to record the student activities and to present a review of college life at Rolla.

"The Missouri Miner," a college weekly, was established in 1915, with the following officers:

General Manager—Fred Grotts, 1916.

Editor in Chief—J. L. Head, 1916.

Business Manager—G. E. Johnson, 1916.

Associates—J. J. Dowd, 1916; W. V. Bayha, special; J. J. Doyle, 1916; W. H. McCartney, 1916.

Student Council.

In order to promote various student enterprises and activities and to maintain a spirit of mutual confidence in the student body and the faculty, there exists in the School of Mines a "Student Council," composed of representatives from the four classes. A committee of the faculty meets with the "Student Council" at all regular meetings and acts in an advisory capacity.

The representatives of the classes for 1914-1915 are:

Senior—H. M. Wilson, J. R. Maher, E. H. Ruebel, Greene Erskine.

Junior—J. A. Worley, W. H. McCartney, B. W. Adams.

Sophomore—J. H. Evans, B. E. Tate, Jr.

Freshman—L. J. Zoller.

The members of the Faculty Advisory Committee for 1914-1915 are:

Dr. A. L. McRae, Chairman.

Dr. G. H. Cox.

Dr. J. W. Barley.

Professor C. R. Forbes.

ATHLETICS.

The School encourages rational athletics and has provided an instructor in physical training who has entire supervision of the physical training of students and of all intercollegiate sports. Occasional privileges are granted to athletic teams, but prolonged absences from work are not permitted.

The Jackling Field provides for baseball, football, and other games, and an ample number of tennis courts have been laid out and are maintained in good order. Suitable dressing-rooms and shower-baths are provided in a temporary building on the athletic field. The Forty-seventh Assembly appropriated Seventy Thousand Dollars for a fireproof gymnasium. This will be thoroughly equipped and will contain a swimming-pool, a running-track, and various other features. Suitable gymnasium apparatus is supplied and indoor games can be carried on during the winter months. A general athletic association exists among the students.

School of Mines Athletic Association.

The purpose of the association is to unite the efforts of the School of Mines in athletic sports. The officers of the association, together with the Faculty Athletic Committee, have the management of the various athletic teams and supervise all intercollegiate athletic contests. The association maintains football, baseball, basketball, and track teams and encourages other games and sports.

All students are eligible to membership in the Athletic Association upon payment of an annual athletic fee of $10.00.

The officers of the Association are:

President ..... Fred Grotts, 1916
Vice-President ..... Prof. J. W. Barley
Secretary ..... J. Charles Miller, 1916
Treasurer ..... Edwin Kahlbaum, Registrar
Student Manager ..... W. H. McCartney, 1916
Cheer Leader ..... G. H. Kublin, 1917
Board of Control ..... Professor Cox and Dennie Messrs. Grotts, McCartney and Kahlbaum

THE MISSOURI MINING ASSOCIATION.

The objects of the Mining Association are: To advance the knowledge of mining among its members; to promote good fellowship among the students and alumni of the School of Mines and others interested in mining, and to bring the School of Mines into closer relation with the mining profession at large. The membership consists of alumni and students in the School of Mines who have to their credit eighty-five semester hours.

The officers of the Association are:

President ..... W. M. Benham, 1915
Vice-President .....F. L. Johnson, 1916
Secretary ..... H. A. Neustaedter, 1916
Treasurer ..... D. W. Blaylock, 1915

EXPENSES

Tuition Fee.

Tuition is free to all students who are residents of Missouri. At a meeting held in October, 1908, the Board of Curators voted that "From and after January 1, 1909, non-residents of Missouri who matriculate in any Department of the University be required to pay a tuition fee of $20.00 per year."

Laboratory Fees.

The fees charged are as follows: An incidental and library fee of $5.00 a year, payable upon entrance; a laboratory fee in general chemistry to cover the cost of gas and supplies, $10.00 a semester; a laboratory fee in qualitative analysis of $10.00 a semester to cover the cost of general supplies and gas, a laboratory fee for quantitative analysis and Senior and Junior chemistry laboratory work, $2.00 a semester; a fee of $2.50 a semester to cover the cost of supplies for shop work; a fee of $2.50 a semester to cover the cost of fuel and supplies in forge work; a fee of $2.50 a semester to cover supplies in machine shop; a fee of $25.00 a semester to cover the cost of supplies and fuel in the assay laboratory; a fee of $5.00 a semester for metallurgy laboratory; a fee of $4.50 a semester for mineralogy laboratory; a fee of $2.50 for diploma; a gymnasium and athletic fee of $5.00 a semester.

Excursion Expenses.

The cost of field excursions will average about $50.00 a year. The total expenses of all trips in the four-year mining curriculum is about $200.00.

Contingent Deposits.

A deposit of $15.00 is required from each student to cover the cost of extra supplies and damage to apparatus. This deposit must be renewed if at any time exhausted, and at the end of the school year whatever sum may remain to the credit of the depositor is returned to him.

Annual Expenses.

The following is an estimate of the heaviest items of the student's expenses. As personal tastes vary widely, no estimate of total expenses is offered:

Room rent, nine months, $5.00 to $10.00 per month, average $65.00
Board, thirty-six weeks, $4.00 per week, average..... 144.00
Fees, excluding tuition 55.00
Drawing instruments (first year) and books..... 25.00

FEES IN MINE ENGINEERING CURRICULUM

FRESHMAN YEAR.

First Semester.

Matriculation	$5.00
Contingent Deposit*	15.00
Tuition (free for Missouri students)	$10.00
General Chemistry Laboratory	10.00
Shop Work	2.50
Athletic Fee	5.00

Second Semester.

Tuition (free for Missouri students)	$10.00
Qualitative Analysis Laboratory	10.00
Forge	2.00
Athletic Fee	5.00

SOPHOMORE YEAR

First Semester.

Matriculation	$5.00
Contingent Deposit*	15.00
Tuition (free for Missouri students)	$10.00
Quantitative Analysis Laboratory	2.00
Mineralogy	4.50
Athletic Fee	5.00

Second Semester.

Tuition (free for Missouri students)	$10.00
Quantitative Analysis Laboratory	2.00
Mineralogy	4.50
Athletic Fee	5.00

*This is a deposit to cover extra supplies and breakage. An account is kept with each student and at the end of the school year whatever sum may remain to the credit of the depositor is returned to him.

JUNIOR YEAR.

First Semester.

Matriculation	$5.00
Contingent Deposit*	15.00
Tuition (free for Missouri students)	10.00
Forge and Machine Shop	2.50
Athletic Fee	5.00

Second Semester.

Tuition (free for Missouri students)	$10.00
Assaying	25.00
Athletic Fee	5.00

SENIOR YEAR

First Semester.

Matriculation	$5.00
Contingent Deposit*	15.00
Tuition (free for Missouri students)	10.00
Metallurgy Laboratory	5.00
Athletic Fee	5.00

Second Semester.

Tuition (free for Missouri students)	$10.00
Athletic Fee	5.00
Diploma Fee	2.50

*This is a deposit to cover extra supplies and breakage. An account is kept with each student and at the end of the school year whatever sum may remain to the credit of the depositor is returned to him.

JACKLING LOAN FUND

Loans may be made to students of the School of Mines from the Jackling Loan Fund under the following conditions:

1. The student must have been in attendance at the School of Mines one semester.

2. Written requests for loans must be filed with the Director, to be considered at the following meeting of the Executive Committee.

3. Loans may be made to students who cannot give security provided they present the endorsement of the Director of the School and a responsible party not connected with the school.

4. No loans of more than one hundred dollars may be made to any one student during the calendar year.

5. The student shall give his note for the amount of the loan, which note shall bear interest at the rate of five per cent per annum from the date of the note to one year after his graduation or his leaving the School of Mines, and for one year following at the rate of eight per cent per annum. The note shall then become due.

The purpose of the Jackling Loan Fund is to help worthy students who require financial assistance and who are unable to borrow money from other sources.

THE MINING EXPERIMENT STATION

Officers of the Station.

Albert Ross Hill, Ph. D., LLD.	*President of the University.*
Austin Lee McRae, S. D. - -	*Director.*
Durward Copeland, S. B. -	*Metallurgy and Ore Dressing.*
Carroll Ralph Forbes, E. M. -	*Mining.*
Victor Hugo Gottschalk, M. S.	*Chemistry.*
Guy Henry Cox, M. A., Ph. D., E. M.	*Geology and Mineralogy.*
Alexis Xavier Illinski, B. S. -	*Station Assistant.*

The Mining Experiment Station was established June 1, 1909.

It is the object of the Station to conduct such original researches or to verify such experiments as relate to the properties and uses of mineral products; to investigate the engineering problems connected with the mineral industry, the economic methods of mining and the preparation of mineral products, the methods of preventing waste of the mineral resources and the methods of preventing accidents in mines, mills, and smelters; to assist in improving the conditions surrounding the labor in mines, mills, and smelters; and such other researches or experiments as bear directly upon the application of mining and metallurgical engineering to the mineral industry of the State of Missouri.

The staff of the Station is carrying on investigations on Missouri lead, zinc, and iron ores and on practical problems of interest to operators of coal and metal mines.

Bulletins published by the station are mailed free of charge to citizens of Missouri.

BUREAU OF GEOLOGY AND MINES

The Geological Survey of the State of Missouri has its headquarters at Rolla, and occupies the Rolla Building on the school campus.

Board of Managers.

GOVERNOR ELLIOTT W. MAJOR, Jefferson City.
President.
ELIAS S. GATCH, St. Louis.
Vice-President.
CLARK CRAYCROFT, Joplin.
Secretary.
EDWARD M. SHEPARD, Springfield.
Chairman of Publication Committee.
PHILIP N. MOORE, St. Louis.

Staff of the Geological Survey.

H. A. BUEHLER,
State Geologist.
F. C. GREENE,
Geologist.
STUART ST. CLAIR,
Geologist.
OTTO VON SCHLICHTER,
Geologist.
G. B. CORLESS,
Geologist.
M. E. WILSON,
Geologist.
A. F. TRUEX,
Assistant Geologist.
WM. HOGOBOOM,
Assistant Geologist.
R. P. RINKER,
Chemist.
J. J. DOYLE,
Chief Clerk.

Equipment and Investigations.

The Geological Survey has at the present time a library of

approximately five thousand volumes and pamphlets on geological and allied subjects, and a museum of seven thousand specimens of clay, coal, barite, lead and zinc ore, iron ore, and other mine and quarry products of Missouri.

The Geological Survey is organized principally to aid in the development of the mineral resources of Missouri. Information concerning these resources is gathered through observations in the field by members of the staff. Geologic and topographic maps are prepared of different parts of the State and the various formations are accurately described in accompanying reports. The relation of the geology to the ore deposits is also worked out and detailed reports published concerning such investigations.

The Department has the following reports available for distribution at the present time:

Preliminary Report ..... Vol. XIII.
Geology of Miller County..... Vol. I., 2d series.
Quarrying Industry of Missouri..... Vol. II., 2d series.
Geology of Moniteau County..... Vol. III., 2d series.
Geology of the Granby Area..... Vol. IV., 2d series.
Public Roads ..... Vol. V., 2d series.
Lime and Cement Resources of Missouri.. Vol. VI., 2d series.
Geology of Morgan County..... Vol. VII., 2d series.
Geology of Pike County..... Vol. VIII., 2d series.
Geology of the Disseminated Lead Deposits of St. Francois and Washington counties ..... Vol. IX., 2d series.
Iron Ores of Missouri ..... Vol. X., 2d series.
Coal Deposits of Missouri ..... Vol. XI., 2d series.
Geology of the Rolla Quad ..... Vol. XII., 2d series.

DEGREES CONFERRED IN 1914

COMMENCEMENT EXERCISES MAY 29, 1914.

Engineer of Mines.

True Walter Blake, B. S. 1911.
Guy Henry Cox, Ph. D., Wisconsin, 1912.
Carlos Enrique Elmore Guerra, B. S. 1911.
Matthew Vincent Quinn, B. S. 1905.
Harvey Edson Smith, B. S. 1910.
Arthur Fuller Truex, B. S., Rochester, 1908.

Master of Science.

Theodore Saunders Dunn, B. S. 1910.

Bachelor of Science in Mine Engineering.

Leonidas James Boucher.
Tirso Castillon.
Claude Calvin Cushwa.
Clyde Willis Hall.
Howard Gove Halsey.
William Coryell Hogoboom.
Gilbert Frank Metz.
Frederick Galloway Moses.
Thomas Robson.
Riley Marsh Simrall.
Edmond Otis Stoliker.
Walter Henry Wager.

Bachelor of Science in Metallurgy.

Joseph Cooper Finagin, Jr. Thaddeus Reamy Goldsborough.

Bachelor of Science in Civil Engineering.

Enoch Ray Needles.

Bachelor of Science in General Science.

George Elmer Abernathy.
Gustav Axel Hellstrand.
Mervin Joe Kelly.
Llewelyn Lodwick.
Roy Nicoll McBride.
Julius Charles Miller, Jr.
Orion Dexter Neal.
John Nixon Webster.

STUDENTS OF THE MISSOURI SCHOOL OF MINES AND METALLURGY

1914-1915

Graduate Students.

Boyer, Fred Tete* ..... *Philadelphia, Pa.*
B. S. in M. E., 1909, School of Mines.

Boyer, George Hewitt* ..... *Milwaukee, Wis.*
B. S. in M. E., 1908, School of Mines.

Bridge, Josiah ..... *Cincinnati, Ohio*
A. B., 1913, University of Cincinnati.

Brooks, John M., Jr. ..... *Knoxville, Tenn.*
B. S. in M. E., 1906, School of Mines.

Clayton, Charley Yancey ..... *Rolla, Mo.*
B. S. in Met., 1913, School of Mines.

Conover, Cairy C.* ..... *Springfield, Ill.*
B. S. in M. E., 1912, School of Mines.

Duffy, Ralph Earl ..... *Rolla, Mo.*
B. S. in E. E., 1909, University of Missouri.

Dunn, Theodore Saunders* ..... *Rapid City, S. D.*
B. S. in G. S., 1910; M. S., 1914, School of Mines.

Dye, Robert Emmett* ..... *Cobalt, Ont., Canada*
B. S. in M. E., 1912, School of Mines.

Harris, George William* ..... *Pachuca, Mex.*
B. S. in Chem. and Met., 1904, School of Mines.

Ingram, John Charavelle ..... *St. Louis, Mo.*
B. S. in G. S., 1913, School of Mines.

Johnson, Edward Mackey* ..... *Denver, Colo.*
B. S. in Chem., 1892, School of Mines.

Kline, Duane Montgomery* ..... *Buckhorn, Nev.*
B. S. in M. E., 1912, School of Mines.

Lodwick, Lewellyn ..... *El Oro, Mex.*
B. S. in G. S., 1914, School of Mines.

Lumaghi, Octavius Louis ..... *St. Louis, Mo.*
Ph. B., 1914, Yale University.

Lynton, Edward Dale* ..... *Morenci, Ariz.*
B. S. in M. E., 1912, School of Mines.

*In absentia.

Maveety, Roswell Hare* ..... *South Bethlehem, Pa.*
B. S. in M. E., 2912, School of Mines.
Miller, Julius C., Jr. ..... *Joplin, Mo.*
B. S. in G. S., 1914, School of Mines.
McNutt, Vachel Harry* ..... *Tulsa, Okla.*
B. S. in M. E., 1910; M. S., 1912, School of Mines.
Neal, Orion Dexter ..... *Linton, Ind.*
A. B., 1913, Indiana University, B. S., 1914; School of Mines.
Radcliffe, Donald Hewson ..... *Rolla, Mo.*
B. S. in G. S., 1913, School of Mines.
Robson (Cuellar), Thomas ..... *Potosi, Bolivia.*
B. S. in M. E., 1914, School of Mines.
Sickly, Robert Glenn* ..... *Cobalt, Ont., Canada*
B. S. in Met., 1913, School of Mines.
Stroup, Thomas Andrew* ..... *Quincy, Ill.*
B. S. in M. E., 1912, School of Mines.
Thornberry, Martin Harmon ..... *Rolla, Mo.*
B. S. in G. S., 1912, School of Mines.
Thornhill, Edward Bryant* ..... *Cobalt, Ont., Canada*
B. S. in M. E., 1908, School of Mines.
Wander, Ernest ..... *Alton, Ill.*
B. S. in M. E., 1910, School of Mines.

Seniors.

Benham, Willard Miles ..... *Elvins, Mo.*
Blaylock, Daniel Webster ..... *Flat River, Mo.*
Clark, Horace Herbert ..... *Chicago, Ill.*
Cowman, Gerard Hoopes ..... *Rolla, Mo.*
Cummings, Lester Merriken ..... *Rolla, Mo.*
Dean, Reginald Scott ..... *Rolla, Mo.*
Elliott, William ..... *Rolla, Mo.*
Gammeter, Walter ..... *St. Louis, Mo.*
Gleason, Augustus Wilhelm ..... *Rolla, Mo.*
Griffin, Roy Watson ..... *Cleveland, O.*
Johnson, Frank Lindley ..... *Rolla, Mo.*
Kaplan, Abe Lew ..... *St. Louis, Mo.*
Kayser, Edwin Alexander ..... *St. Louis, Mo.*
Maher, John Ralph ..... *Rolla, Mo.*
McCague, Thomas Purcell ..... *Rolla, Mo.*
Ruebel, Ernest H., Jr. ..... *St. Louis, Mo.*
Schroer, Edward Albrecht ..... *Clayton, Mo.*
Shotwell, John Warden ..... *St. Louis, Mo.*
Trent, Albert Leo ..... *Rolla, Mo.*
Weissbach, Walter William ..... *Rolla, Mo.*
Wilson, Homer Marvin ..... *Rolla, Mo.*

*In absentia.

Juniors.

Adams, Bernard William ..... *Hamilton, Mo.*
Allen, James John ..... *St. Louis, Mo.*
Ashdown, Byron L. ..... *St. Louis, Mo.*
Bennett, Roy Linwood ..... *Raton, N. Mex.*
Beyer, Emil ..... *St. Louis, Mo.*
Boyer, Ray Vernon ..... *Tarkio, Mo.*
Boyle, Wallace Haley ..... *Centralia, Mo.*
Burg, Robert Stanley ..... *Rolla, Mo.*
Casanovas, Juan Rafael ..... *Baracoa, Cuba.*
Cole, Joseph Bryant ..... *Rolla, Mo.*
Craig, Robert ..... *Osage, City, Kan.*
Damotte, Edward Victor ..... *Rolla, Mo.*
Deutman, Earl George ..... *Rolla, Mo.*
Dowd, James Joseph ..... *St. Louis, Mo.*
Doyle, John J. ..... *St. Louis, Mo.*
Dunham, Azman Thurman ..... *Rolla, Mo.*
Ehlers, Louis Wilmer ..... *Baltimore, Md.*
Erskine, Lucian ..... *St. Louis, Mo.*
Erskine, Greene ..... *St. Louis, Mo.*
Fairchild, Donald H. ..... *Paxton, Ill.*
Galbraith, John Gray ..... *Joplin, Mo.*
Galloway, Ralph Arthur ..... *Hutchinson, Kan.*
Gannon, Kenrick Irving ..... *St. Louis, Mo.*
Gold, Charles ..... *St. Louis, Mo.*
Grotts, Fred ..... *Rolla, Mo.*
Hayden, Roy Wilber, Jr. ..... *Urich, Mo.*
Head, James Lawrence ..... *Moberly, Mo.*
Heimberger, Harry Tobias ..... *Rolla, Mo.*
Heman, Fred ..... *Fort Dodge, Iowa.*
Hoffman, John Stone ..... *Leon, Iowa.*
Hoover, Louis McLin ..... *Rochester, Ind.*
Hoppock, Louis Needham ..... *Lebanon, Mo.*
James, Floyd Dixie ..... *Rolla, Mo.*
Johnson, Gunnard Edmund ..... *Rolla, Mo.*
Jones, Earl Ambrose ..... *Rolla, Mo.*
Kamp, William Henry ..... *St. Louis, Mo.*
Kiskaddon, William Walter ..... *Rolla, Mo.*
Klepel, Yaro ..... *St. Louis, Mo.*
Kline, Harry Daniel ..... *Rolla, Mo.*
Koch, Hugo Edward ..... *Creve Coeur, Mo.*
Krebs, Joseph Jackson ..... *Lake Charles, La.*
Lawrence, Nathaniel Morris ..... *St. Louis, Mo.*
Lesniak, Stanislaw Wojciech ..... *Rolla, Mo.*
Lillingston, Howard Emerson ..... *Webster Groves, Mo.*
Lyons, Leo Daniel ..... *Springfield, Mo.*

Miller, Elton Arthur ..... *Rolla, Mo.*
Miller, John Charles ..... *St. Louis, Mo.*
Mit, Otto Robert ..... *Joplin, Mo.*
Morgan, Donald Hawk ..... *St. Louis, Mo.*
Mountjoy, Richard Leroy ..... *Webb City, Mo.*
McCartney, William Henry, Jr. ..... *Webster Groves, Mo.*
McNely, Earl Joesting ..... *Alton, Ill.*
Neustaedter, Harold Arthur ..... *Jersey City, N. J.*
O, Alejandro B. de la..... *El Paso, Tex.*
Peterson, Clarence Eugene ..... *Schenectady, N. Y.*
Sailer, Edward Louis ..... *Rolla, Mo.*
Scheurer, Leroy Robert ..... *Rolla, Mo.*
Schuman, John Morris ..... *Rolla, Mo.*
Skidmore, Myron ..... *Carlyle, Ill.*
Smith, Virgil X. ..... *Rolla, Mo.*
Stifel, Carl Godfried ..... *St. Louis, Mo.*
Tompkins, Edwin See ..... *Rolla, Mo.*
Turnbull, Louis Alan, Jr. ..... *Kirkwood, Mo.*
Ude, George Edgar ..... *Rolla, Mo.*
Vogel, Herman ..... *Rolla, Mo.*
Weiberg, Earl Burdette ..... *Springfield, Ill.*
Wenner, Paul H. ..... *Bartlesville, Okla.*
Worley, James Alexander, Jr. ..... *San Antonio, Tex.*

Sophomores.

Aid, Kenneth ..... *Gallatin, Mo.*
Ambler, Harry Atwood ..... *St. Louis, Mo.*
Barker, Lyle Maxon ..... *Chamberlain, S. D.*
Barton, Joe ..... *Montgomery City, Mo.*
Bayha, Wilson Varley ..... *St. Louis, Mo.*
Blair, Albert Watson ..... *Rolla, Mo.*
Bock, James Henry, Jr. ..... *Rolla, Mo.*
Bowles, Martin Frady ..... *Neodesha, Kan.*
Brown, John Stafford ..... *Milford, Mo.*
Burkhart, Edgar Carl ..... *Macon, Mo.*
Chapman, Howard Alonzo ..... *Rolla, Mo.*
Cooper, Richard ..... *St. Louis, Mo.*
Couch, James Roscoe ..... *Parkville, Mo.*
Cowen, Warden Henry ..... *Beardstown, Ill.*
Dale, Ralph ..... *Herrin, Ill.*
Dolman, Phillips Brooks ..... *St. Joseph, Mo.*
Elfred, Frank Stillman, Jr. ..... *St. Joseph, Mo.*
Evans, James Herschel ..... *Rolla, Mo.*
Freudenberg, Walter Harry ..... *St. Louis, Mo.*
Gerber, Theodore C. ..... *Washington, D. C.*
Greenberg, David ..... *Kirkwood, Mo.*

Hampsch, Oswald Harold ..... *Henderson, Ky.*
Heimberger, Karl Wm. ..... *Rolla, Mo.*
Heavner, Alonzo Westcott ..... *Humansville, Mo.*
Henschel, Ramsey Coleman ..... *Kansas City, Mo.*
Hippard, Clemence William ..... *Belleville, Ill.*
Houston, Homer James ..... *Newburg, Mo.*
Huff, Clarence Mayfield ..... *Ironton, Mo.*
Kahlbaum, William ..... *Rolla, Mo.*
Kaplan, Louis ..... *St. Louis, Mo.*
Keeling, Orval ..... *Rolla, Mo.*
Klein, Carl E. ..... *Farmington, Mo.*
Kluge, Harry Albert ..... *Collinsville, Ill.*
Kublin, George H. ..... *St. Louis, Mo.*
Langdon, Albert Jewett, Jr. ..... *Ironton, Mo.*
Lucky, Maurice Cecil ..... *Cassville, Mo.*
Lyons, Robert ..... *Springfield, Mo.*
Martin, Thomas Herbert ..... *Pocahontas, Ark.*
Meador, Carlos Delmar ..... *Rolla, Mo.*
Mize, Charles Roderick ..... *Independence, Mo.*
McComb, William Randolph ..... *St. James, Mo.*
Nevin, James Raymond ..... *Ottumwa, Iowa.*
Pape, Paul Frederick ..... *Cape Girardeau, Mo.*
Powell, William Clark ..... *Rolla, Mo.*
Pugh, James Willard ..... *Kansas City, Mo.*
Raible, Joseph C., Jr. ..... *Hannibal, Mo.*
Reilly, John Gay ..... *St. Louis, Mo.*
Rice, Hugh Prentice ..... *Rolla, Mo.*
Ritter, Norton Elijah ..... *Joplin, Mo.*
Robards, Robert Russell ..... *Miami, Okla.*
Rossman, Kenneth Van Bergen..... *St. Louis, Mo.*
Schiermeyer, Harry J. ..... *St. Louis, Mo.*
Shaw, William Allen ..... *St. Louis, Mo.*
Shayes, Fred Pine ..... *Rolla, Mo.*
Shipley, John Joshua ..... *Kansas City, Mo.*
Shotwell, Phillip Bassett ..... *St. Louis, Mo.*
Shriver, Ray Otto ..... *Newton, Kan.*
Steele, Oliver W. ..... *Dallas, Tex.*
Tate, Benjamin Edward..... *St. Louis, Mo.*
Teas, Howard Jones ..... *Freeport, N. Y.*
Velasco, Rafael E. ..... *Rolla, Mo.*
Walsh, John Kennedy ..... *St. Louis, Mo.*
Walsh, Thomas Patrick Francis..... *St. Joseph, Mo.*
Weeks, Albert L. ..... *Arenzville, Ill.*
Wiggins, Clarence Allen ..... *Carthage, Mo.*
Wilson, George Baldwin ..... *Rolla, Mo.*
Wilson, Joseph Griswold ..... *St. Louis, Mo.*
Wood, John Skinner ..... *Rolla, Mo.*
Young, John Toomer ..... *Rolla, Mo.*

Freshmen.

Askew, Walter Howard ..... *Aberdeen, S. D.*
Bagby, Robert Edwin ..... *New Haven, Mo.*
Balderson, Vearle Weiss ..... *Atchson, Kan.*
Bardsley, Clarence Edward ..... *St. Louis, Mo.*
Barrere, George Cady ..... *St. Louis, Mo.*
Bitterberg, Henry Edward ..... *St. Louis, Mo.*
Bowman, Charles Randolph ..... *St. James, Mo.*
Brandenburger, Walter Otto ..... *Belleville, Ill.*
Brazill, M. P., Jr. ..... *St. Louis, Mo.*
Cameron, R. D. ..... *St. Louis, Mo.*
Canavan, Thomas Jefferson ..... *E. St. Louis, Ill.*
Chavez, Raul ..... *St. Louis, Mo.*
Clark, Harvey Smith ..... *Kansas City, Mo.*
Corby, Harry Gilbert ..... *Carthage, Mo.*
Cox, James ..... *St. Louis, Mo.*
Cox, William Ray ..... *Sullivan, Mo.*
Craig, Jack Throckmorton ..... *Dallas, Tex.*
Dake, Ralph ..... *Rolla, Mo.*
Dawson, Thomas L. ..... *Kansas City, Mo.*
Decker, Ernest E. ..... *Tulsa, Okla.*
Doeling, Victor Hugo ..... *Hannibal, Mo.*
Doennecke, Henry William ..... *Davenport, Iowa.*
Doran, Homer Martin ..... *Wellsville, Kan.*
Dover, Fayette Lee ..... *St. Louis, Mo.*
Ebmeyer, Gerard E. ..... *Lincoln, Nebr.*
Epperson, Charles Lee ..... *Joplin, Mo.*
Etem, Charles August ..... *Hickman Mills, Mo.*
Ferguson, William Hays, Jr. ..... *Mound City, Mo.*
Fiedler, John Ray ..... *Shelbyville, Ind.*
Flanders, Jerome Emerson ..... *Paris, Mo.*
Fleming, James Taafe ..... *St. Louis, Mo.*
Goldman, Leon Harrison ..... *St. Louis, Mo.*
Golick, Tony Frank ..... *Canton, Ill.*
Gordon, Roy Newman ..... *Farmington, Mo.*
Gorman, Fay Osborne ..... *Kansas City, Mo.*
Halley, Henry Clay ..... *Auxvasse, Mo.*
Harbicht, Harlan Carl ..... *Hannibal, Mo.*
Henson, Nacy Frank ..... *Sikeston, Mo.*
Imlay, John Logan ..... *Stacy, Minn.*
Jamison, Glen Thomas ..... *Joplin, Mo.*
Kennedy, George Brice ..... *Atlanta, Tex.*
Kern, Paul ..... *Monroe City, Mo.*
Lawrence, Hiram Pettibone ..... *St. Louis, Mo.*
Long, Emery Hubert ..... *St. Joseph, Mo.*
Lyon, Joe Newlin ..... *Robinson, Ill.*

Mack, Otis Forrest ..... *Granby, Mo.*
Maher, Lawrence ..... *St. Louis, Mo.*
Maness, Orie Newell ..... *Webb City, Mo.*
Massey, Robert Lee, Jr. ..... *Omaha, Nebr.*
Meadows, Harold Orland ..... *Licking, Mo.*
Miller, Edwin Lawrence ..... *Kansas City, Mo.*
Mitchell, Leslie Rae ..... *Farmington, Mo.*
Moore, Chauncey Clark ..... *Kansas City, Mo.*
Morris, John Munson ..... *Farmington, Mo.*
Murphy, Earle ..... *Vinita, Okla.*
McCann, Edgar ..... *Monroe City, Mo.*
Nichols, Benjamin Guthrie ..... *St. Louis, Mo.*
Olson, Oscar Adolph ..... *Gwinn, Mich.*
Ore, Felipe B. ..... *Lima, Peru.*
Papin, Joseph Emmett ..... *Esther, Mo.*
Pearman, James Errol ..... *Carthage, Mo.*
Pink, Eugene Michel ..... *DeSoto, Mo.*
Potts, Allen Dewey ..... *Swedeborg, Mo.*
Reber, William Houston ..... *Dallas, Tex.*
Rennick, Daniel McCurdy ..... *Philadelphia, Pa.*
Rogers, Robert Wells ..... *Chicago, Ill.*
Rucker, Ambrose Chockley ..... *Keytesville, Mo.*
Rutherford, Raymond Elmer ..... *Mt. Vernon, Ill.*
Schnaidt, Charles Michael ..... *St. Louis, Mo.*
Sides, Harry J. ..... *Webb City, Mo.*
Skeen, Leslie Carlisle ..... *St. Louis, Mo.*
Stahl, Horace Reynolds ..... *Quincy, Ill.*
Stoner, Oscar Eli ..... *Chester, Nebr.*
Strawn, Harry Omar ..... *Washington, D. C.*
Strobach, Lester Fred ..... *Rolla, Mo.*
Stroup, Richard John ..... *Quincy (West), Mo.*
Stutzer, Harry Frankiln ..... *Kansas City, Mo.*
Terry, Mark Loren ..... *Jamesport, Mo.*
Valentine, Herman Frederick ..... *Marshall, Mo.*
Whittam, Lester Vivian ..... *Fair Grove, Mo.*
Wilson, Eldred Dewey ..... *Rolla, Mo.*
Wood, Frank Albert ..... *Rolla, Mo.*
Zeuch, Walter Charles ..... *St. Louis, Mo.*
Zoller, Lawrence Joseph ..... *Rolla, Mo.*

Special Students.

Allen, Lillian ..... *Rolla, Mo.*
Bland, Clark C. ..... *Rolla, Mo.*
Copley, Charles Francis ..... *Mahoney City, Pa.*
Dent, Bertha M. ..... *Rolla, Mo.*
Freeman, Earl ..... *St. Louis, Mo.*

Hanrahan, James ..... *Rolla, Mo.*
Milsted, Nell ..... *Rolla, Mo.*
Scanlan, Frank Dailey ..... *Newburg, Mo.*
Smith, Marshall Raymond ..... *Rolla, Mo.*
White, Kenrick ..... *Rolla, Mo.*

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